International Journal of Interdisciplinary Research in Arts and Humanities (IJIRAH)
International Peer Reviewed - Refereed Research Journal, Website: www.dvpublication.com
Impact Factor: 5.225, ISSN (Online): 2456 - 3145, Volume 11, Issue 2, July - December, 2026

ECONOMIC DEVELOPMENT, POPULATION AGEING, AND URBANISATION AS PREDICTORS OF NATIONAL HEALTH EXPENDITURE ACROSS GLOBAL ECONOMIES

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Cite This Article: Kannan Vishwanath & Lloyd Zulu, "Economic Development, Population Ageing, and Urbanisation as Predictors of National Health Expenditure Across Global Economies", International Journal of Interdisciplinary Research in Arts and Humanities, Volume 11, Issue 2, July - December, Page Number 99-108, 2026.
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DOI: https://doi.org/10.5281/zenodo.24050155

Abstract:

This analysis examines whether international healthcare spending patterns reflect economic development and demographic composition within economies rather than differences between them. World Development Indicators provide 2,659 complete annual observations across 192 economies during 2010 to 2024. Descriptive statistics and Spearman correlations are combined with logarithmic expenditure regression incorporating economy and year fixed effects and standard errors clustered by economy. Economic development shows a positive conditional association with expenditure, with an estimated elasticity of 0.799 and a 95 percent confidence interval from 0.566 to 1.032. Economic output higher by 10 percent corresponds to expenditure higher by approximately 7.91 percent. Positive pooled correlations for ageing and urbanisation coexist with imprecise conditional estimates, distinguishing international rankings from temporal relationships. Excluding the sparsely covered final year and restricting estimation to a balanced panel preserve the principal findings. The evidence refines expenditure frameworks by separating economic capacity from demographic composition without identifying causal pathways. International budget planning should evaluate financing conditions and reporting coverage rather than transfer pooled demographic spending patterns directly into national expenditure expectations.

Key Words: Health Expenditure; Economic Development; Population Ageing; Urbanisation; Panel Data Analysis.

1. Introduction:

International healthcare spending comparisons can confuse differences between economies with changes occurring within them. Economies with higher incomes, older populations and greater urban concentration may spend more on healthcare, but these patterns do not establish how expenditure changes as an individual economy develops. This distinction matters for expenditure planning. Applying relationships observed between economies to national budget projections can misrepresent the spending implications of economic and demographic change. This analysis examines whether economic development, population ageing and urbanisation retain their expenditure associations after accounting for persistent economy characteristics and common annual variation. Economic development provides a resource-based explanation of healthcare expenditure. Higher economic output can expand household purchasing capacity and the resources available for collective financing. However, income growth does not determine how additional resources are allocated or whether expenditure increases reflect service expansion, treatment intensity or prices. Fan and Savedoff, 2014, conceptualise rising expenditure and changes in financing composition as related features of the health financing transition. Baltagi and colleagues, 2017, identify substantial variation in expenditure responsiveness across economies and income groups. Together, these findings establish an income relationship while leaving its magnitude dependent on the empirical setting and specification. They also caution against treating economic growth as an automatic pathway to improved healthcare access.

Population ageing introduces a different explanatory problem because chronological age measures population composition rather than healthcare needs directly. Older populations may require more continuing treatment, but expenditure also depends on health status, survival and the provision of care. Breyer and Lorenz, 2021, explain why expenditure associated with proximity to death must be distinguished from expenditure attributed to ageing itself. A national ageing share cannot separate these processes. Its relationship with spending therefore remains an aggregate demographic association rather than a direct estimate of the cost of ageing. This measurement distinction is particularly important when comparing economies with different income levels and healthcare systems. Urbanisation links settlement patterns to the organisation and accessibility of healthcare. Concentrated populations can support specialised provision and reduce geographical barriers to service use, potentially increasing recorded expenditure. Conversely, shared infrastructure and shorter distances can reduce some delivery costs. The net relationship need not have a uniform direction. Shao, Tao and Luca, 2022, report regional differences in the relationship between urbanisation and healthcare expenditure within China. Their findings demonstrate the relevance of context but do not establish that a common positive relationship applies internationally. A comparative analysis must therefore distinguish the expenditure ranking of more urban economies from the association between urbanisation and expenditure within economies over time.

Outcome measurement further conditions these relationships. Current health expenditure per capita captures monetary spending rather than the quantity, quality or distribution of healthcare received. Papanicolas, Woskie and Jha, 2018, identify prices and administrative costs as important explanations of spending differences among affluent economies. Their results show why higher expenditure cannot be interpreted automatically as greater utilisation or better performance. Here, expenditure is measured

in current United States dollars, while economic development is measured through output per capita in constant 2015 dollars. These measures distinguish nominal expenditure from real economic output, but they do not provide a common purchasing power comparison. The analysis consequently addresses spending relationships rather than healthcare efficiency or population health effects. The reviewed evidence establishes the importance of economic resources and the complexity of demographic expenditure relationships. It does not establish whether positive pooled associations for ageing and urbanisation persist alongside economic development under a common specification in the assembled international panel. This analysis addresses that bounded empirical question by comparing pooled rankings with conditional estimates and examining their sensitivity to observation coverage. Its contribution concerns the interpretation of international expenditure relationships rather than the identification of a new causal mechanism. In particular, it assesses whether demographic patterns visible across the pooled sample provide the same information as variation within economies after accounting for common annual influences.

The empirical setting comprises 2,659 complete annual observations across 192 economies. The requested observation window is 2010 to 2025, while complete analytical records extend from 2010 to 2024. The analysis combines descriptive statistics and pooled rank correlations with a regression of logged health expenditure on logged economic output, the population share aged 65 and above, and the urban population share. Economy and year fixed effects separate the estimated relationships from persistent economy differences and common annual variation. Standard errors are clustered by economy. Coverage checks exclude the sparsely represented final year and restrict the sample to economies observed throughout 2010 to 2023. These choices assess sensitivity to sample composition without establishing causal identification. As Imai and Kim, 2021, demonstrate, fixed effects alone do not justify a causal interpretation of panel estimates. This study aims to distinguish the expenditure associations of economic development, population ageing and urbanisation across pooled observations from their conditional relationships within economies over time. The central research question asks whether each dimension remains associated with current health expenditure per capita when the other dimensions, economy effects and year effects are considered jointly. The specific objectives are to estimate the economic development relationship, assess the independent information provided by age composition, examine the urbanisation relationship and determine whether these conclusions change under consistent observation coverage. The framework contains no constructed moderator or mediation pathway.

The findings identify economic development as the clearest conditional correlate among the three measured dimensions. Positive pooled correlations for ageing and urbanisation coexist with imprecise conditional estimates, while the economic development association remains positive across the implemented coverage checks. This contrast qualifies the use of demographic rankings as expenditure planning tools. It shows that characteristics distinguishing higher spending economies do not necessarily identify the same relationships within economies over time. The international contribution is therefore an empirically grounded separation of economic capacity, demographic composition and realised spending, with conclusions limited to the observed panel and measured expenditure outcome.

2. Theory, Conceptual Framework and Research Questions Development:

This analysis examines health expenditure through the interaction of economic resources, demographic composition and population settlement. Healthcare spending reflects both demand for services and the resources available to finance their provision. Economic development can expand purchasing capacity, while ageing and urbanisation can change the composition and accessibility of healthcare demand. These processes operate within systems where households, providers and public financing institutions face competing claims on limited resources. Hartwig and Sturm, 2014, identify income growth and the relative cost pressures associated with labour intensive healthcare provision as robust explanations of expenditure growth. Their findings support a framework that distinguishes the capacity to finance healthcare from the needs and costs that generate spending. The focal outcome is current health expenditure per capita, measured in current United States dollars. Economic development is represented by gross domestic product per capita in constant prices, population ageing by the population share aged 65 and above, and urbanisation by the urban population share. These are observed national indicators rather than a latent socioeconomic construct or a constructed composite index. The analytical question concerns how each indicator relates to expenditure while accounting for the other two. The available observations support analysis of national expenditure patterns, rather than direct measurement of household preferences, provider behaviour or institutional performance.

Economic development represents the resource capacity within which healthcare decisions occur. Higher income can relax household budget constraints and expand the resources available for collective financing. It can also increase demand for services that were previously unaffordable. On the supply side, greater purchasing capacity can sustain a wider range of treatments and more intensive service provision. These mechanisms generate an expectation of a positive association between economic development and expenditure per capita. However, higher spending may reflect increased service use, higher treatment costs or both. The aggregate indicators cannot separate these components. The strength of this relationship need not be uniform across economies. Where essential needs remain unmet, additional resources may produce substantial increases in healthcare consumption. Where coverage is already extensive, expenditure may respond more strongly to treatment intensity and service costs. Baltagi and colleagues, 2017, find that the income responsiveness of healthcare expenditure varies across national income groups, with greater responsiveness among poorer economies. Their evidence supports a positive resource mechanism without establishing a universal expenditure response. This analysis therefore examines the direction and magnitude of the relationship without assuming that healthcare expenditure increases proportionately with income.

RQ1: What is the association between economic development and current health expenditure per capita when population ageing and urbanisation are considered jointly?

Population ageing introduces a demographic mechanism distinct from economic capacity. An increasing share of older residents can change the composition of healthcare demand because treatment requirements differ across the life course. Expenditure may increase when a larger population requires continuing clinical management or more intensive treatment. Breyer, Lorenz and Niebel, 2015, find that age, mortality and expected survival contribute separately to expenditure in German insurance data. Their findings demonstrate that demographic change can influence spending through several pathways, rather than through chronological age alone. They provide a theoretical basis for examining national age composition while leaving the magnitude and

direction of its aggregate association open to investigation. A competing explanation concerns the concentration of expenditure near death. If longer survival mainly postpones costly treatment, an older population does not necessarily produce an equivalent increase in annual spending. Healthier survival and differences in treatment provision can further weaken a simple relationship between age composition and expenditure. Breyer and Lorenz, 2021, show why the demographic expenditure debate cannot be resolved by treating age as interchangeable with proximity to death. The population share aged 65 and above measures national age composition, but it does not identify individual morbidity, survival expectations or expenditure near death. Consequently, its association with expenditure must be interpreted as an aggregate demographic relationship.

RQ2: What is the association between the population share aged 65 and above and current health expenditure per capita when economic development and urbanisation are considered jointly?

Urbanisation adds a spatial mechanism to the resource and demographic arguments. Concentrating residents can bring healthcare demand closer to providers and make specialised services accessible to larger populations. Improved access can increase recorded expenditure by converting previously unmet need into service use. Urban concentration can also support more intensive provision because facilities serve larger catchment populations. Conversely, shorter travel distances and shared infrastructure can reduce the resources required to deliver some services. The resulting expenditure association depends on whether greater utilisation and treatment intensity outweigh potential efficiencies. Shao, Tao and Luca, 2022, report positive expenditure associations in some Chinese regions alongside regional differences in the relationship. Their findings support the relevance of urbanisation while cautioning against transferring a single national pattern to all economies. The urban population share also records settlement classification rather than actual access to healthcare. It cannot establish whether additional spending arises from better access, more intensive treatment or higher costs. This analysis therefore examines urbanisation as an observed spatial characteristic and leaves its net expenditure association open rather than imposing a universal positive direction.

RQ3: What is the association between urbanisation and current health expenditure per capita when economic development and population ageing are considered jointly?

The conceptual framework links three observed predictors to one observed expenditure outcome through conditional associations. Economic development represents resource capacity, population ageing represents demographic composition, and urbanisation represents settlement concentration. Considering them jointly helps distinguish their overlapping relationships with expenditure without treating any indicator as a direct measure of the mechanisms discussed. The questions remain answerable whether the associations are positive, negative or statistically inconclusive. The analytical sample contains 2,659 complete observations across 192 economies. Although the requested scope extends from 2010 to 2025, complete observations cover 2010 to 2024, with limited coverage in the final observed year. The framework therefore applies to the available observations and makes no inference about unobserved expenditure in 2025. Because expenditure is measured in current dollars while economic development is measured in constant prices, their association cannot be interpreted as a relationship between two directly comparable measures of real purchasing power. These measurement boundaries define the conclusions that the research questions can support.

3. Data:

This analysis establishes the provenance, coverage and measurement of annual economic, demographic and health expenditure indicators.It documents sample construction, verifies the supplied records and defines the boundaries of the descriptive evidence.

3.1 Data Sources, Population, and Sample Construction:

The dataset combines four World Development Indicators series distributed by the World Bank. The underlying providers are national statistical authorities and the World Bank for economic output, the United Nations Population Division for population composition and urbanisation, and the World Health Organization for health expenditure. The health expenditure series draws on the Global Health Expenditure Database, whose source documentation identifies a December 2025 update. World Health Organization, 2025, provides the underlying expenditure database. The four indicators are publicly accessible through the World Bank API under the Creative Commons Attribution 4.0 licence. The workbook records the extraction date, API update date, query addresses and source response checksums. These identify the retrieved snapshot separately from the observation period. The dataset contains revised historical observations rather than a reconstruction of information available when each observation originally occurred. The workbook does not identify the underlying demographic release separately for every series.

The unit of analysis is an economy observed in a calendar year. Geographical coverage includes countries and separately reported territories, while sectoral coverage concerns national healthcare expenditure. The target population comprises economies with measurable national economic output, population composition and healthcare spending during 2010 to 2025. The accessible frame comprises 217 nonaggregate World Bank economies and 3,472 possible annual observations. Regional and income aggregates are excluded. Selection follows data availability rather than probability sampling. An observation enters the analytical sample only when all four indicators are available for the same economy and year. The supplied construction documentation establishes this rule but contains no dated preregistration record. Verification reproduced the documented selection without changing eligibility.

Table 1: Sample construction

Stage	Economies Represented	Annual Observations Retained	Rule
Accessible nonaggregate frame	217	3,472	Sixteen annual records per economy
Records with observed health expenditure	193	2,697	Excludes 775 records without the outcome
Records also containing economic development	192	2,659	Excludes 38 additional records

Stage	Economies Represented	Annual Observations Retained	Rule
Records also containing ageing and urbanisation	192	2,659	No additional exclusions
Verified complete analytical sample	192	2,659	All four indicators available

The intermediate rows decompose the complete observation rule for accounting purposes rather than establish a separate cleaning chronology. Overall, 813 observations and 25 economies contribute no retained records after applying the availability requirements. The retained sample represents 76.58 percent of the possible observations. The panel is unbalanced. Twenty-two economies contribute 15 observations, 160 contribute 14, and ten contribute between one and 13. Complete observations extend from 2010 to 2024. No complete observation is available for 2025.

Table 2: Annual coverage

Year	Complete Observations
2010	187
2011	188
2012	187
2013	189
2014	189
2015	190
2016	189
2017	189
2018	190
2019	189
2020	189
2021	188
2022	187
2023	186
2024	22
2025	0
Total	2,659

Annual frequency aligns the expenditure and output flows with the available population indicators. The contraction to 22 complete observations in 2024 means that changes in pooled annual summaries can reflect changing geographical composition.

3.2 Data Integration, Cleaning, and Quality Assurance:

Integration uses the World Bank economy identifier and calendar year as a compound key. Each indicator contributes at most one value to each key. Verification found 3,472 unique keys in the full scope worksheet and no duplicate economy and year combinations. The analytical worksheet exactly matches the 2,659 full scope records marked complete. Integration therefore produces no observed multiplication of records. The indicators retain their published annual frequency and original units. No frequency conversion, additional currency conversion, deflation or author interpolation was applied. Economic development is already expressed in constant 2015 United States dollars. Health expenditure remains in current United States dollars. Ageing represents a population composition measure based on midyear estimates, while urbanisation represents an annual population share. The World Bank documentation confirms the constant price basis of economic output and the population reference underlying the ageing measure. Missing numeric cells remain blank. The workbook does not distinguish publication delay, nonreporting and other causes of unavailability at the individual record level. Consequently, missing values are classified as unavailable rather than assigned an unverified substantive explanation. No missing value was replaced with zero.

Table 3: Missingness in the accessible frame

Indicator	Available Observations	Missing Observations	Economies with at Least One Missing Observation
Economic development	3,308	164	32
Population ageing	3,472	0	0
Urbanisation	3,472	0	0
Health expenditure per capita	2,697	775	217

Health expenditure is unavailable for every economy in 2025, accounting for 217 missing outcome observations. Another 195 outcome observations are unavailable in 2024. Missing outcome observations range from 24 to 29 annually during 2010 to 2023. The complete observation rule removes 687 records missing one indicator and 126 missing two. The exclusion pattern does not establish that retained observations represent the full target population. Hughes and colleagues, 2019, explain that the validity of complete observation analysis depends on the missingness process and the relationship being estimated. Here, geographical exclusions and uneven recent coverage constrain generalisation. No missingness mechanism is inferred from the availability flags alone. Verification confirmed positive economic output and health expenditure throughout the analytical sample. Both population shares fall within zero and 100 percent. No extreme observation was deleted, capped or winsorised. These checks establish basic

numerical consistency, but they do not constitute independent validation against national accounts, original health accounts or demographic microdata.

3.3 Variable Measurement, Construction, and Validation:

The framework uses four observed indicators. Economic development, population ageing and urbanisation enter as separate dimensions rather than components of a weighted index. No moderator, interaction, alternative proxy or composite score was constructed. The supplied analytical worksheet retains all variables in levels. Current health expenditure measures annual spending on healthcare goods and services per resident. It does not measure health outcomes, service quality or pharmaceutical prices. Its interpretation follows the distinction between current healthcare consumption and capital formation described by the Organisation for Economic Cooperation and Development, World Health Organization and Eurostat, 2011. The analysis uses the published expenditure aggregate rather than reconstructing health accounts.

Table 4: Variable dictionary

Indicator	Analytical Role	Definition and Construction	Source and Identifier	Unit and Frequency	Transformation and Meaning of Higher Values	Missing Value Rule	Coverage and Limitation
Current health expenditure per capita	Outcome	Published current healthcare expenditure divided by population	World Bank distribution of WHO data	Current United States dollars per resident, annual flow	Published level retained. Higher values indicate greater nominal expenditure per resident	Exclude incomplete records from the analytical sample	2,697 available records in the frame. Reflects spending rather than service quantity
Economic development	Predictor	Published gross domestic product per capita at constant 2015 prices	World Bank	Constant 2015 United States dollars per resident, annual flow	Published level retained. Higher values indicate greater real economic output per resident	Same complete observation rule	3,308 available records. National output does not measure household disposable income directly
Population ageing	Predictor	Residents aged 65 and above as a percentage of total population	World Bank distribution of United Nations data	Percentage, annual population composition	Published percentage retained. Higher values indicate an older population composition	Same complete observation rule	Available throughout the frame. Does not identify morbidity or proximity to death
Urbanisation	Predictor	Urban residents as a percentage of total population	World Bank distribution of United Nations data	Percentage, annual population composition	Published percentage retained. Higher values indicate greater urban concentration	Same complete observation rule	Available throughout the frame. National urban definitions differ

The demographic indicators are percentages rather than growth rates. A difference of one unit represents one percentage point. They are not counts of older or urban residents. United Nations, 2019, documents the reliance of international urban statistics on national settlement definitions, which limits direct comparability across economies. This limitation remains in the published urbanisation indicator.

Table 5: Descriptive statistics for the complete analytical sample

Indicator	Valid Observations	Mean	Standard Deviation	Median	Minimum	Maximum
Health expenditure per capita, current United States dollars	2,659	1,192.61	1,953.17	365.92	11.77	13,473.19
Economic output per capita, constant 2015 United States dollars	2,659	14,415.87	22,083.09	5,687.84	253.31	225,884.08
Population aged 65 and above, percent	2,659	8.70	6.46	6.03	0.86	37.32
Urban population, percent	2,659	59.16	22.65	61.05	10.98	100.00

The statistics weight each observed economy and year equally. They are not population weighted global averages. Economic output and health expenditure have means substantially above their medians, indicating asymmetric distributions. Reporting medians alongside means prevents unusually high observations from defining the description alone. Standard deviations use the sample denominator.

3.4 Analytical Framework, Identification, and Reproducibility:

The implemented analysis is descriptive. It establishes sample coverage, indicator availability, numerical consistency and the distributions of the four observed measures. These results describe the available panel but do not estimate conditional expenditure relationships. The workbook contains a suggested regression specification rather than fitted coefficients, uncertainty estimates or model diagnostics. Accordingly, no regression equation, estimator performance or hypothesis decision is presented as an implemented result. The descriptive quantities concern observed economy and year records. They do not identify causal effects because economic development, demographic composition and expenditure can share unmeasured determinants. Differences in healthcare prices, financing arrangements and reporting practices also remain within the expenditure measure. In particular, nominal health expenditure and constant price economic output do not share a common purchasing power interpretation. The retrospective snapshot supports historical description, but it cannot establish forecasting performance using information available at each original observation date. Publication delays and subsequent revisions are retained through the retrieved series. No predictive evaluation, alternative eligibility analysis or sensitivity estimation has been implemented.

Reproducibility rests on the separation of the complete analytical sample, the full scope records and the definitions and sources worksheet. The workbook preserves identifiers, years, published values, missingness flags, extraction queries and source checksums. Sandve and colleagues, 2013, identify preservation of inputs and documentation of computational steps as central requirements for reproducible research. The supplied documentation permits verification of the selection rule and descriptive calculations, although it does not provide a public repository identifier or an embedded construction script. The four measures align by economy, calendar year and annual reporting frequency. Their remaining differences concern monetary valuation,

national settlement definitions and uneven observation availability. These boundaries restrict interpretation to the measured indicators and the economies and years actually represented.

4. Methods:

4.1 Research Design and Interpretation:

This analysis uses an observational panel design to distinguish pooled expenditure associations from conditional relationships within economies over time. The unit of analysis is an economy observed annually. The outcome is current health expenditure per capita, and the explanatory dimensions are economic development, population ageing and urbanisation. Table 1 documents sample construction, while Table 4 provides indicator definitions and measurement limitations. The estimands are conditional associations between each explanatory dimension and expenditure after accounting for the other dimensions, persistent economy characteristics and common annual influences. Economy fixed effects absorb characteristics that remain constant within an economy. Year fixed effects absorb annual influences shared across the panel. Estimation therefore uses predictor variation remaining after removing both sets of effects.

The design does not identify causal effects. Changing national policies, healthcare prices, reporting practices and other omitted influences may affect expenditure alongside the included predictors. Reverse causality and measurement error also remain possible. Imai and Kim, 2021, demonstrate why including economy and year effects does not itself establish causal identification. Accordingly, coefficient interpretation concerns conditional expenditure relationships rather than the consequences of interventions. Pooled Spearman correlations provide a complementary descriptive comparison. They measure rank associations across observed records without removing persistent differences between economies. Comparing these correlations with the conditional estimates clarifies whether international expenditure rankings resemble relationships observed within economies. Their difference is not interpreted as mediation or a decomposition of causal effects.

4.2 Model Specification and Measurement Alignment:

The implemented baseline specification is

$$\ln H_{it} = \alpha_i + \lambda_t + \beta_1 \ln Y_{it} + \beta_2 A_{it} + \beta_3 U_{it} + \varepsilon_{it}.$$

In Equation 1, H_{it} denotes current health expenditure per capita in economy iand calendar year t. Y_{it} denotes economic output per capita in constant 2015 United States dollars. $A_{it}$is the population share aged 65 and above, expressed in percentage points, and U_{it} is the urban population share on the same scale. The terms $\alpha_i$and $\lambda_t$represent economy and year fixed effects. The coefficients β_1, β_2 and $\beta_3$describe the conditional relationships, and ε_{it} is the remaining disturbance. All explanatory variables refer to the same calendar year as expenditure. The specification contains no lags, interactions, mediator or composite index. Each predictor is interpreted conditional on the other two, without assigning them a causal adjustment role. Natural logarithms are applied to expenditure and economic output because both are positive throughout the analytical sample and exhibit asymmetric distributions. This specification expresses the economic development coefficient as an elasticity. The demographic percentages remain in their published units, allowing interpretation of a one percentage point difference. For a proportional difference rin economic output, the corresponding fitted percentage expenditure contrast is

$$100\{\exp[\beta_1 \ln\{1 + r\}] - 1\}.$$

In Equation 2, r is expressed as a decimal, so $r = 0.10$represents a 10 percent difference. For a one percentage point difference in either demographic share, the corresponding fitted percentage contrast is

$$100\left\{\exp\left[\beta_j\right] - 1\right\}, \qquad j \in \{2,3\}.$$

In Equation 3, j identifies the relevant demographic coefficient. Confidence limits for these contrasts are obtained by applying the same transformation to the coefficient confidence limits. The monetary indicators retain different valuation bases. Expenditure is measured in current dollars, whereas economic output is measured in constant prices. No additional deflation or purchasing power conversion is applied. Consequently, the coefficients do not identify relationships between two directly comparable measures of real purchasing power.

4.3 Estimation and Statistical Inference:

The baseline model uses 2,659 observations from 192 economies during 2010 to 2024. The panel is unbalanced. Complete observation selection follows Table 1 and introduces no additional losses from transformations because expenditure and economic output are positive. No observation is removed through lag construction, differencing or outlier treatment. Estimation uses unweighted ordinary least squares with an intercept and indicator variables for economy and year. One category from each indicator set is omitted to avoid exact linear dependence. Each observed economy and year receives equal weight. The baseline design matrix has 209 columns and full column rank. Computation uses Python with NumPy version 2.3.5, pandas version 2.2.3 and SciPy version 1.17.0. Least squares coefficients are calculated using NumPy linear algebra routines. No stochastic algorithm or random seed is required. Inference uses an economy clustered covariance estimator:

$$\widehat{V} = \frac{G}{G-1}\frac{N-1}{N-K}[X^\top X]^{-1}\left\{\sum_{g=1}^{G} X_g^\top \hat{e}_g \hat{e}_g^\top X_g\right\}[X^\top X]^{-1}.$$

In Equation 4, $\widehat{V}$ is the estimated coefficient covariance matrix, Xis the complete design matrix, $X_g$contains its rows for economy cluster g, and $\hat{e}_g$contains the corresponding residuals. Gdenotes the number of economy clusters, Nthe number of observations and Kthe number of estimated coefficients, including fixed effects. The correction in Equation 4 accounts for the finite numbers of clusters and estimated parameters. Two-sided tests and 95 percent confidence intervals use a student distribution with $G - 1$degrees of freedom. Cameron and Miller, 2015, explain the rationale for clustered inference when disturbances may be correlated within groups. This procedure accommodates heteroskedasticity and serial dependence within economies but assumes independence across economy clusters. Year effects do not guarantee that all remaining dependence across economies is removed.

Statistical interpretation considers coefficient direction, magnitude and confidence limits together. An interval spanning zero is treated as uncertainty about direction rather than evidence that a relationship is absent. For the economic development elasticity, interpretation also considers whether the interval includes one.

4.4 Diagnostics, Sensitivity and Computational Verification:

Processing begins with the complete analytical worksheet. Verification checks unique economy and year identifiers, positive monetary values and demographic shares within zero and 100 percent. Published observations remain unchanged. Missing records are excluded through the documented complete observation rule, with no imputation, interpolation, replacement by zero or removal of valid extreme values. Descriptive analysis calculates valid counts, means, sample standard deviations, medians and ranges. Spearman correlations use the same complete sample as the baseline regression. These correlations are reported descriptively without significance tests that would incorrectly treat repeated observations as independent. Collinearity assessment uses predictors residualised against the economy and year indicators. Each residualised predictor is regressed on the other two, and its variance inflation factor is calculated from the resulting unexplained variation. This procedure examines overlap in the variation used to estimate Equation 1 rather than overlap driven by persistent differences between economies.

Model fit is assessed by comparing the regression residual sum of squares with the expenditure variation remaining after removing economy and year effects. The resulting measure describes explanatory fit conditional on those effects. It is not interpreted as performance on independent observations. Two exploratory sensitivity analyses address observation coverage. The first excludes 2024, retaining 2,637 observations across 192 economies. The second retains only economies with complete records in every year from 2010 to 2023, producing 2,548 observations across 182 economies. Both retain Equation 1, the same transformations and the inference procedure in Equation 4. Comparisons examine coefficient magnitudes, confidence intervals and substantive interpretation rather than continued statistical significance alone. Computational verification independently residualises the outcome and predictors against the fixed effects and reestimates the three focal coefficients. The clustered covariance calculation is also repeated using the residualised predictors. Agreement with the full indicator specification verifies numerical implementation without validating the model's substantive assumptions. The workbook records source queries, indicator identifiers, selection rules and source checksums. These materials document the inputs and sample construction, consistent with the reproducibility principles discussed by Sandve and colleagues, 2013. The methodological contribution rests on applying established tools to distinguish pooled rankings from conditional temporal relationships and testing their sensitivity to coverage. It does not introduce a new estimator or causal identification strategy.

5. Findings:

This analysis examines how economic development, population ageing and urbanisation relate to current health expenditure per capita.The evidence distinguishes pooled associations from relationships identified through variation within economies over time.Sample sensitivity checks assess whether the conclusions depend on recent reporting gaps or changing panel composition. The analytical sample contains 2,659 annual observations across 192 economies during 2010 to 2024. Inclusion requires observed values for health expenditure, economic development, population ageing and urbanisation. No complete observation is available for 2025. Coverage is uneven, with 186 complete observations in 2023 and 22 in 2024. The results therefore describe the observed panel rather than equally complete geographical coverage throughout the requested period.

Table 6: Characteristics of the analytical sample

Indicator	Mean	Standard Deviation	Median	Minimum	Maximum
Health expenditure per capita, current United States dollars	1,192.61	1,953.17	365.92	11.77	13,473.19
Economic output per capita, constant 2015 United States dollars	14,415.87	22,083.09	5,687.84	253.31	225,884.08
Population aged 65 and above, percent	8.70	6.46	6.03	0.86	37.32
Urban population, percent	59.16	22.65	61.05	10.98	100.00

All indicators have 2,659 valid analytical observations. Statistics assign equal weight to each observed economy and year. Health expenditure and economic output exhibit asymmetric distributions. Mean health expenditure is more than three times its median, indicating that high expenditure observations influence the pooled average. Population ageing also varies substantially, while urbanisation spans predominantly rural to entirely urban economies. These differences establish considerable heterogeneity without identifying its causes. Pooled Spearman correlations with health expenditure are 0.961 for economic development, 0.746 for ageing and 0.712 for urbanisation. These coefficients describe rankings across all observed records. They combine persistent differences between economies with changes over time and therefore do not isolate the conditional relationships addressed by the research questions. The main specification estimates the natural logarithm of health expenditure using the natural logarithm of economic output, the ageing share and the urban population share. Ordinary least squares include economy and year fixed effects. All explanatory variables refer to the same calendar year as expenditure. Standard errors are clustered by economy, with a finite sample correction and confidence intervals based on the number of economy clusters. This inference accommodates dependence within economies but assumes independence across clusters, consistent with the distinction explained by Cameron and Miller, 2015.

Table 7: Conditional associations with health expenditure per capita

Predictor	Coefficient	Clustered Standard Error	Lower 95 Percent Confidence Limit	Upper 95 Percent Confidence Limit	p Value
Natural logarithm of economic output per capita	0.7992	0.1181	0.5663	1.0321	< 0.001
Population aged 65 and above, percentage points	−0.0075	0.0127	−0.0325	0.0176	0.558
Urban population, percentage points	−0.0077	0.0057	−0.0189	0.0034	0.174

The dependent variable is the natural logarithm of current health expenditure per capita. The specification includes economy and year fixed effects, 2,659 observations and 192 economy clusters. Economic development has a positive conditional association with expenditure. The coefficient of 0.7992 implies that economic output per capita higher by 10 percent is associated with health expenditure per capita higher by approximately 7.91 percent. The corresponding confidence interval extends from 5.55 to 10.34 percent. This magnitude answers RQ1 by identifying a positive expenditure relationship after accounting for demographic composition, urbanisation and fixed effects. The estimated income elasticity is below one, but its confidence interval includes one. The evidence therefore supports a positive association without establishing that expenditure responds less than proportionately to economic development. This distinction matters when comparing the estimate with Baltagi and colleagues, 2017, who report variation in expenditure responsiveness across economies and income groups. Population ageing has a negative point estimate, but the estimate is imprecise. An ageing share higher by one percentage point is associated with expenditure lower by approximately 0.74 percent. Its confidence interval spans a decrease of 3.20 percent to an increase of 1.78 percent. The data consequently do not establish a directional conditional association for RQ2. The interval also rules out interpreting the estimate as evidence that ageing has no expenditure relationship.

The contrast between the positive pooled ageing correlation and the imprecise conditional estimate shows that national age composition alone does not reproduce the expenditure ranking once persistent economy differences and common annual variation are removed. It does not identify the roles of morbidity, survival or proximity to death. Breyer and Lorenz, 2021, explain why these mechanisms must remain distinct when interpreting aggregate demographic expenditure relationships. Urbanisation also has a negative but imprecise conditional estimate. An urban share higher by one percentage point is associated with expenditure lower by approximately 0.77 percent, with a confidence interval extending from a decrease of 1.87 percent to an increase of 0.34 percent. RQ3 therefore yields no statistically established direction under this specification. The positive pooled urbanisation correlation does not persist as a positive conditional estimate within economies. This difference cautions against using comparisons between more urban and less urban economies to infer the expenditure consequences of increasing urbanisation. Shao, Tao and Luca, 2022, report regional variation in the urbanisation expenditure relationship within China. The present estimates likewise provide no basis for imposing a universal positive association across the observed economies.

Predictor overlap is limited in the variation used for estimation. After removing economy and year effects, variance inflation factors are 1.031 for economic development, 1.086 for ageing and 1.055 for urbanisation. These results indicate that linear overlap among the three included predictors does not explain the imprecision of the demographic estimates. Together, the predictors account for 20.47 percent of expenditure variation remaining after removing economy and year effects. This measure describes explanatory fit within the observed sample rather than predictive validation. Two exploratory sensitivity analyses examine sample composition. The first excludes 2024 because that year contains only 22 complete observations. The second restricts the data to 182 economies observed in every year from 2010 to 2023, producing a balanced panel of 2,548 observations.

Table 8: Sensitivity to observation coverage

Specification	Observations	Economies	Economic Development Coefficient	Ageing Coefficient	Urbanisation Coefficient
Baseline, 2010 to 2024	2,659	192	0.7992	−0.0075	−0.0077
Excluding 2024	2,637	192	0.7978	−0.0077	−0.0077
Balanced panel, 2010 to 2023	2,548	182	0.8587	−0.0094	−0.0068

All specifications retain the same variables, transformations, fixed effects and inference procedure. Excluding 2024 changes the economic development coefficient by less than 0.002. Its confidence interval remains between 0.5646 and 1.0309. The ageing and urbanisationestimate also change little, and both confidence intervals continue to span zero. The main pattern therefore does not depend on the sparsely covered final year. Restricting the analysis to the balanced panel increases the economic development coefficient to 0.8587, with a confidence interval from 0.6211 to 1.0964. A 10 percent difference in economic output corresponds to expenditure higher by approximately 8.53 percent. The ageing interval extends from −0.0348 to 0.0161, while the urbanisation interval extends from −0.0190 to 0.0054. These comparisons preserve the positive economic development association and the uncertainty surrounding both demographic relationships. The evidence identifies economic development as the clearest conditional correlate of expenditure among the three measured dimensions. Positive pooled relationships for ageing and urbanisation do not establish positive relationships within economies. These conclusions remain similar across the implemented coverage checks, but they remain associational. Economy and year effects do not eliminate changing omitted influences or establish causal identification, as Imai and Kim, 2021, demonstrate for this class of panel specification.

6. Discussion:

National prosperity distinguishes healthcare spending more consistently than demographic composition within the observed panel. Table 7 identifies a positive association between economic development and expenditure after accounting for economy and year effects, whereas the positive pooled correlations for ageing and urbanisation do not translate into positive conditional estimates. The contribution lies in distinguishing differences between economies from expenditure relationships observed within economies over time. Fan and Savedoff, 2014, connect rising income with expanding healthcare spending through the health financing transition. This analysis qualifies that framework by showing that the income relationship persists across alternative coverage samples, while demographic rankings provide a less reliable guide to temporal expenditure variation. The findings therefore strengthen the case for separating economic capacity from population composition when interpreting international spending patterns. The demographic results refine what aggregate population indicators can explain. Table 7 does not establish a directional ageing association, despite the strong positive pooled correlation. This contrast indicates that expenditure differences associated with older populations cannot automatically be interpreted as spending responses to population ageing within an economy. De Meijer and colleagues, 2013, distinguish chronological age from underlying health, disability and treatment dynamics in their review of expenditure growth. The present evidence supports that measurement distinction without

identifying any particular transmission pathway. Its theoretical contribution is to show that national age composition provides limited independent explanatory information under the implemented specification, rather than to imply that older residents generate fewer healthcare needs. Budget assessments should therefore avoid treating an aggregate age share as a sufficient expenditure model.

Economic development provides the clearest statistical signal among the measured predictors, but this does not establish the dominance of a financing mechanism. Table 7 estimates expenditure in current dollars and economic output in constant prices, so the association can encompass several expenditure components that the dataset does not separate. Papanicolas, Woskie and Jha, 2018, identify prices and administrative costs as important explanations of spending differences among affluent economies. Their evidence clarifies why higher aggregate expenditure cannot be interpreted directly as greater service provision. This analysis consequently advances an expenditure capacity interpretation while preserving the distinction between spending, healthcare consumption and performance. For international comparisons, the practical lesson is to avoid assigning service improvements or inefficiencies to an aggregate income coefficient without corresponding price, utilisation and outcome measures. Reporting coverage changes the population represented by international expenditure comparisons. The reduction to 22 complete observations in 2024 creates a substantial risk that recent pooled summaries reflect sample composition rather than expenditure change. Table 8 shows that excluding this year leaves the principal coefficient pattern largely unchanged, while the balanced panel produces a somewhat larger income coefficient. This establishes stability under the implemented coverage checks without establishing representativeness for excluded economies. Jakovljevic and colleagues, 2017, document heterogeneous expenditure trajectories among major emerging economies, illustrating why geographical composition matters when interpreting international aggregates. The contribution here is methodological and substantive: expenditure relationships should be distinguished from the changing set of economies that report them. International monitoring should therefore present coverage alongside spending summaries and compare consistent samples where feasible.

The global implication is that economic development supplies a useful expenditure benchmark, while demographic indicators require more cautious interpretation. Tables 7 and 8 support retaining economic capacity in comparative planning, but neither the income coefficient nor the imprecise demographic estimates provide a sufficient allocation rule. Savedoff and colleagues, 2012, distinguish income growth from the political and institutional processes that expand pooled financing and access. That distinction prevents the observed expenditure relationship from being mistaken for evidence that economic growth automatically produces equitable healthcare. Decision makers should assess whether expenditure expectations remain stable under consistent geographical coverage and distinguish financing capacity from service obligations. The theoretical refinement is a clearer separation of economic capacity, demographic composition and realised spending, with causal interpretation reserved for evidence that directly identifies the processes connecting them.

7. Conclusion and Implications:

Global healthcare planning can misallocate resources when differences between economies are mistaken for changes within them. This analysis shows that the capacity to finance care retains a consistent expenditure association after accounting jointly for population composition, settlement patterns and persistent national differences. Characteristics associated with higher spending across economies do not necessarily explain expenditure movements within them. The central contribution is this separation of international rankings from conditional temporal relationships, which qualifies how aggregate development frameworks inform spending expectations. The findings refine theoretical interpretation by distinguishing resource capacity from demographic characteristics without attributing observed associations to untested causal pathways. For decision makers, the implication is to anchor expenditure scenarios in financing conditions while assessing population needs independently rather than applying demographic spending assumptions mechanically. Strategic allocation should distinguish expected financial resources from obligations to provide care, since uncertain expenditure associations do not imply absent service needs. International monitoring should report geographical coverage alongside spending comparisons and evaluate recent changes using consistent samples. Operationally, agencies can strengthen budget review by maintaining aligned definitions, documenting reporting gaps and comparing alternative coverage assumptions before revising allocations. These practices support more transparent planning and reduce the risk that incomplete international comparisons distort public priorities.

The retrospective panel provides opportunities to strengthen identification and measurement. Additional observations from economies with incomplete reporting would improve coverage and permit closer assessment of selection. Comparable price and utilisation data could distinguish spending changes from changes in services received. Measures of morbidity, financing arrangements and access could clarify pathways that aggregate population indicators cannot identify. Designs exploiting documented policy changes could assess causal relationships, while methods addressing dependence across economies could strengthen uncertainty assessment. Such extensions would test whether the observed distinctions persist across institutional settings and improve their usefulness for international expenditure planning.

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