Effects of Governance and Public Health Spending: An Empirical Evidence from a Panel-Corrected Standard Errors Approach to Improving the Quality of Life in Arab Economies

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Abstract: Quality of life (QoL) in the Arab world hinges on credible institutions and effective social spending; yet evidence linking governance, health budgets, and environmental pressures remains fragmented and seldom extends beyond 2020. This study clarified these links by assembling a balanced panel of 14 Arab countries from 2000–2020 to examine how institutional quality and public health expenditure shaped QoL, while accounting for carbon emissions, economic expansion, and education expenditures. QoL is proxied by life expectancy, while institutional quality is captured through a composite index constructed by applying Principal Component Analysis to the Worldwide Governance Indicators. The analysis employed country- and year-fixed effects, along with panel-corrected standard errors (PCSE), to address heteroskedasticity and cross-sectional dependence. Results indicated that institutional quality was the dominant driver as the composite index was strongly associated with higher QoL ($\beta = 1.843$, $p < .01$). Health expenditure was also crucial though the effect was economically small ($\beta \approx 0.0063$, $p < .05$). Education expenditure was weakly negative ($p < .10$), thus reflecting quality and governance constraints in the education sector. Carbon emissions displayed a small positive coefficient ($\beta \approx 0.0949$, $p < .05$), which likely implied policy and structural weaknesses rather than genuine welfare gains. Moreover, GDP per capita exhibited a statistically significant yet negligible and slightly negative elasticity (≈ -0.000124), indicating rent-dependent growth that failed to translate into improved well-being. Collectively, the findings imply that governance reforms yield the greatest QoL, whereas spending without institutional credibility produces limited returns. Future work should test interaction effects, explore thresholds, and incorporate subjective QoL metrics to guide the sequencing of reforms across Gulf Cooperation Council (GCC) and non-GCC settings.

Keywords: Quality of life; Institutional quality; Health expenditure; Sustainable development; Panel-corrected standard errors

1. Introduction

Quality of life (QoL) in Arab economies depends on whether institutions can convert public resources into services that people actually use. The region experiences aging in some places and a youth bulge in others (ESCWA, 2024); it also faces rising heat stress, air pollution, and fiscal pressures (Samra & Ali, 2025). Therefore, a credible account of what improves well-being should look beyond income. It must examine how governance credibility and health budgets work together under environmental and macroeconomic constraints. However, prior assessments often analyzed these forces one at a time, or they stopped before the Arab Spring and the COVID-19

shock. Consequently, policymakers still lack region-specific elasticities that show how governance reform and health spending influence well-being under conditions of high environmental risk and limited fiscal space. This study answered that need by proposing a simple and transparent empirical design tailored to Arab economies. The approach was grounded in the concept that institutions are the primary channel through which social spending translates into tangible improvements in people's living.

Although this study used data from 2000–2020, its motivation remained directly connected to current regional concerns. In particular, current evaluations (ESCWA, 2024; Samra & Ali, 2025) reported the increasing environmental stress, demographic strains, and institutional constraints in Arab economies. Therefore, our analysis was framed with a pre-2020 baseline that clarified the structural links among governance, health spending, and QoL before the COVID-19 shock. Furthermore, this level was required to interpret current risks and, therefore, to guide post-2020 reforms more effectively.

The empirical setting was the Arab region from 2000 to 2020. This horizon spanned two systemic shocks, the Arab Spring and the pandemic, and several cycles of oil prices. It also spanned reforms in public finance, digital government, and health coverage. As such, it offered the variation needed to identify region-wide relationships while controlling country traits and standard shocks. The study assembled a balanced panel of 14 countries and estimated fixed effects models with panel-corrected standard errors (PCSE). This estimator was appropriate in a region where results were co-moved across boundaries and where error variances varied among nations. It addressed heteroskedasticity and contemporaneous correlation and maintained a clear interpretation of the coefficients. As a result, inference would be sound even when shared shocks and unequal volatility occurred between countries. The quality of institutions, as reflected in governance, regulatory quality, and corruption control, determined how inputs were converted into services and outputs. More effective institutions were more likely to minimise leakages, develop incentives, and perform more efficiently when providing services; therefore, they could increase QoL despite diminishing income growth (Iyoboyi & Musa-Pedro, 2024; Kibria & Toufique, 2023). Health spending was also relevant; however, the location and distribution of budgets determined its influence. When expenditure was absorbed by wage bills or capital outlays that did not enhance coverage or quality, returns were low. Conversely, returns increased when funds were used to support primary care, prevention, and performance (De Luca et al., 2023; Sibanda et al., 2024). Further, the interaction among environmental pressures (i.e., air pollution, heat stress, and carbon-intensive growth), institutions, and health systems influenced life expectancy and well-being (Nica et al., 2023; Rahman et al., 2022). Therefore, any credible QoL model for the Arab region should integrate governance and health spending, with explicit controls for environmental and economic conditions.

Our current study was directly linked to Sustainable Development Goals 3 (good health and well-being) and 16 (peace, justice, and strong institutions). It also aligns with national development roadmaps, including Saudi Vision 2030 and the United Arab Emirates (UAE) Centennial 2071, which prioritize improving citizens' well-being through accountable, digital, and high-performing institutions. Likewise, climate-resilience strategies across the region increasingly target health security, heat-adapted urban design, and pollution control. However, policymaking is often constrained by the piecemeal literature: Many studies isolated either institutional quality or health spending, focused on a single sub-region, or ended before the COVID-19 period (Al-Shboul & Al Rawashdeh, 2022; Hadipour et al., 2023; Uddin et al., 2023). Consequently, decision-makers lack joint elasticities to indicate the impact of reforms in governance and health budgets on QoL under different environmental burdens and economic constraints. In line with these arguments, the objectives of our study are fourfold:

(1) Estimate the elasticities of institutional quality and health expenditure with respect to QoL indices that include life-expectancy-adjusted measures and the Human Development Index (HDI);

(2) Examine the interaction terms that capture whether better institutions amplify the QoL returns to health spending;

(3) Test for sub-regional heterogeneity by comparing the Gulf Cooperation Council (GCC) economies with those of non-GCC economies, recognizing differences in fiscal space, health system maturity, and regulatory enforcement;

(4) Explore the roles of environmental and macroeconomic controls (CO_2 emissions per capita, energy mix, and income per capita), given their documented links to life expectancy and perceived well-being (Nica et al., 2023; Uddin et al., 2023).

The contribution of this paper is threefold. First, it integrates institutional economics and the human-capabilities perspective within an environmental context specific to Arab economies. It argued that well-being depended on the credibility of the rules governing how pubic money was spent on health, and not on fiscal volume alone. Second, it brings together governance, health expenditure, environmental stress, and macro controls into a single and region-wide panel through 2020, with country and year effects and with diagnostics for dependence and cointegration. Thus, it extends the evidence base beyond studies that treat these drivers in isolation or end the sample earlier. Third, it delivers policy-ready elasticities for governance and health budgets, thus helping governments prioritize reforms under fiscal and climate constraints. Therefore, it aligns with Sustainable Development Goals 3 on health and 16 on institutions, and complements national strategies to improve service

delivery, digital accountability, and resilience.

Evidence from developing regions indicates that corruption in health systems increases infant mortality and reduces life expectancy by diverting resources and eroding trust; conversely, credible rules enhance hospital performance and population health (De Luca et al., 2023; Iyoboyi & Musa-Pedro, 2024; Nadpara & Samanta, 2015). On the same note, degradation and exposure to pollutants could reduce life expectancy, which could be mitigated by robust institutions and targeted health spending, especially in urban areas where these risks were most pronounced (Nica et al., 2023; Rahman et al., 2022). Thus, the joint and conditional effects of governance and health spending pose an important question for Arab policymakers, who are facing the challenge of simultaneous fiscal tightening, adaptation to climatic pressures, and social protection.

The rest of the article is organized as follows. Section 2 reviews the relevant literature, thereby positioning the contribution. Section 3 delineates the research gap and, accordingly, states the objectives. Section 4 presents the data, variables, and the econometric approach based on PCSE with fixed effects. Section 5 presents the empirical results, the robustness checks, and interprets their magnitudes. Finally, Section 6l ends with policy implications, limitations, and future research directions.

2. Literature Review

Studies on QoL are numerous but scattered. However, there is consensus that well-being is built through institutions, sectoral expenditure, environmental stressors, and the macroeconomic structure. QoL is a blend of objective achievements (e.g., income, education, and life expectancy) and subjective judgments of life satisfaction and insecurity. Consequently, it sits at the nexus of economics, public health, and environmental studies (Pol et al., 2016; Sen, 2003). In the Arab region, these linkages are particularly salient because resource endowments, institutional legacies, and climate risks vary significantly across countries. Since single-factor explanations are inadequate, this review synthesized global and regional evidence across five strands: institutional quality, health expenditure, environmental degradation, economic growth, and education expenditure, while highlighting methods, strengths, and limitations in each body of work.

2.1 Institutional Quality—Quality of Life Nexus

The evidence linking QoL to institutional quality is substantial yet heterogeneous; studies have therefore employed varied identification strategies. For example, Iyoboyi & Musa-Pedro (2024) analyzed 47 African countries (2006–2018) using two-step system generalized method of moments (system GMM) and found that political stability, voice and accountability, and control of corruption increased QoL, whereas unemployment, rapid urbanization, and CO_2 emissions reduced it. Moreover, income, internet penetration, and education improved outcomes. Similarly, Hadipour et al. (2023) constructed a principal-components composite of the Worldwide Governance Indicators for 158 countries (2001–2020) and estimated fixed effects and GMM models; they found that stronger institutions reduced infant mortality and increased life expectancy, whereas log-CO_2 worsened health and GDP per capita, schooling, total health spending, and urbanization improved it. In the same vein, Omosuyi (2024) employed dynamic ordinary least squares (DOLS), with fully modified OLS (FMOLS) and canonical cointegrating regression (CCR) as robustness checks; his study showed that overall globalization lowered life expectancy in Nigeria unless government effectiveness was high. Correspondingly, the interaction turned the net effect positive, indicating institutional mediation. Furthermore, Ajide et al. (2022) applied system GMM to 45 African economies (2001–2018) and documented that poor electricity access reduced life expectancy, increased infant mortality and health expenditure, and blunted the gains from well-equipped institutions; resulting in infrastructure–governance complementarities. In addition, Menshikov et al. (2014) synthesized comparative evidence and argued that healthcare access and hence QoL rested on economic growth and institutional maturity tempered by social justice. Through these studies, dynamic panel methods have helped address persistence and endogeneity; nevertheless, sub-regional heterogeneity and contemporaneous correlation have often remained under-tested. For a tightly-linked region like the Arab world, PCSE specification is well-aligned with the prevalence of co-movements in energy prices, reform cycles, and regional shocks.

2.2 Health Expenditure—Quality of Life Nexus

The literature on health expenditure and QoL has shown that composition and governance often matter more than volume, and study designs have spanned macro panels, meso-system (regional or organizational) indices, and randomized trials. For instance, Raghupathi & Wu (2011) examined information and communication technologies (ICT), accessibility, quality, affordability, and applications in relation to public-health delivery; their study reported improvements in immunization, sanitation, and life expectancy. They cautioned that ICT primarily enhanced delivery processes but might raise spending, so institutional efficiency mediated returns. Likewise, Bruzzi et al. (2022) constructed non-compensatory composite indices, quality, access, and cost for Italian regional

health systems and demonstrated persistent disparities, including instances where high outlays coexisted with underperformance; hence, spending should align with accessibility and quality to improve QoL. They emphasized that system culture, transparency, and values determined whether budgets led to equitable access and patient-valued outcomes. Furthermore, Hall et al. (2012) evaluated Transition Care Programme in Australia and discovered shorter hospital stays and fewer readmissions, yet limited system-wide cost savings unless QoL gains were explicitly valued. Therefore, budget rules should incorporate health-utility improvements. Taken together, targeted and well-governed spending, especially for prevention, primary care, and delivery redesign raises QoL; in addition, wage-heavy and weakly monitored outlays often yield modest or null effects. Because expenditure is endogenous to need and shocks are spatially correlated, long regional panels estimated with PCSE are particularly applicable to the Arab context.

2.3 Economic Expansion—Quality of Life Nexus

A substantial body of literature has demonstrated that economic growth influences the QoL through human development, social protection, and quality of labor market; however, these pathways are neither linear nor uniform. Mohamed (2020) estimated cointegration and a vector error-correction model (VECM) for Sudan from 1970 to 2015 and revealed a long-run relationship among resource rents, human development, and GDP growth. However, the long-run coefficients indicated that resource rents, school enrollment, life expectancy, and financial development were negatively associated with growth, to be consistent with a resource-curse mechanism via weakened human capital, while development expenditure was growth-enhancing. Likewise, in the same vein, studies using European and American Working Conditions Surveys across 18 countries have shown that poor-quality employment harms health, with effects varying by welfare regime and gender; thus, growth that expands precarious work might not raise QoL. Moreover, Lindgren & Lyttkens (2010) simulated Sweden with a dynamic micro-model and projected rising bed-days and costs under aging and technology diffusion. Consequently, even drastic policies had a limited effect without institutional reform; queues and reliance on private insurance were likely to grow. Using a panel generalized least squares (GLS) model for the 28 European Union member states (EU-28) over the period 2000–2013, Giammanco & Gitto (2019) commented that inward foreign direct investment (FDI) was positively associated with two factors: A higher public share in health financing and better population health to be measured by healthy life years (HLY). Their analysis positioned human infrastructure as the key mechanism linking these macroeconomic outcomes to broader QoL.

2.4 Environmental Degradation—Quality of Life Nexus

Environmental degradation, measured by CO_2 emissions and ecological footprints, undermines QoL both directly and indirectly. Accordingly, recent studies have increasingly relied on second-generation panel estimators to identify these effects. For instance, Uddin et al. (2023) analyzed six Asian economies (2002–2020) using the cross-sectionally augmented Im–Pesaran–Shin (CIPS) unit-root test, cross-sectionally augmented Autoregressive Distributed Lag (CS-ARDL), fully modified OLS (FMOLS), and dynamic OLS (DOLS); they discovered that institutional quality, financial development, and health expenditure lengthened life expectancy, whereas CO_2 emissions and ecological footprints shortened it, with cross-estimator robustness strengthening inference under cross-sectional dependence. Similarly, Guo et al. (2024) examined 23 developing countries (from 2000–2022) using pooled and fixed effects, two-step system GMM, panel ARDL (PARDL), FMOLS/DOLS, and the Dumitrescu–Hurlin panel causality test. Based on their findings, greenhouse gases and energy use raised health expenditure and worsened outcomes, whereas institutional quality and globalization improved life expectancy when paired with sound governance. In addition, Nica et al. (2023) applied CS-ARDL and panel quantile regression (1990–2021) to examine Eastern Europe and concluded that renewable energy, health expenditure, and institutional quality increased life expectancy, whereas use of fossil fuel and CO_2 emissions reduced it; distributional heterogeneity implied different policy levers along the life-expectancy spectrum. Likewise, time-series evidence from Nigeria confirmed directionality: Nwani (2022) used VECM, variance decomposition, and Granger tests (1981–2019) and reported a unidirectional causal effect from air pollution to life expectancy. Moreover, institutional quality, per-capita GDP, social expenditure, agriculture, and school enrollment cushioned the harm, whereas foreign direct investment (FDI) had mixed effects consistent with pollution-haven channels. Furthermore, Alimi & Ajide (2021) employed system GMM for Sub-Saharan Africa (1996–2016) and demonstrated that carbon emissions and ecological footprints reduced life expectancy, increased infant mortality, and increased health spending. In this regard, weak institutions amplified environmental damage, indicating governance thresholds below which regulation failed to protect health. Hence, clean-energy transitions, tougher environmental policy, and institutional strengthening are complements rather than substitutes. Designs that handle contemporaneous shocks and heteroskedasticity are essential in a region with dust storms, energy-price co-movements, and shared geography.

2.5 Education Expenditure—Quality of Life Nexus

Empirical research has indicated that public education expenditure influences QoL through capability formation, higher earnings, and regional well-being; however, returns are contingent on institutional quality and complementary policies. For example, Fagbemi & Adeoye (2019) studied 21 Sub-Saharan African countries (1984–2016) using mean group (MG) and pooled mean group (PMG) estimators. They revealed that in the long run public spending would raise human capital, proxied by primary enrollment and life expectancy, while short-run effects were weak. Furthermore, they emphasized the importance of result-based funding and expenditure control to overcome political and institutional failures that dilute returns. Similarly, Bazie et al. (2024) incorporated corruption in a human-capital model and predicted a GMM on Sub-Saharan African countries (1996–2018). According to their findings, corruption reduced years of schooling and life expectancy and diverted budgets from health and education, thereby undermining the gains of social spending on QoL. In addition, Tu et al. (2021) employed fixed effects models for Vietnamese provinces (2016–2018) and discovered that education and Industry 4.0 proxies, science and technology expenditure, telephone mainlines, and internet users significantly increased earnings; likewise, the provincial competitiveness index strengthened returns, implying that governance complemented education. Moreover, Navarro et al. (2017) developed a composite regional competitiveness index for Spain, combining human-capital pillars such as post-secondary attainment, knowledge infrastructure, and vocational training, and suggested that education capacity correlated positively with territorial well-being. Likewise, evidence from integrated public financial management systems showed that strong measurement infrastructure and expenditure tracking were essential for converting education budgets into effective service delivery and capability expansion (Sandeep & Ravishankar, 2011). Hence, education outlays improve QoL when credible governance ensures allocations, measurement systems track outcomes, and digital and innovation policies enhance the value of skills, implying that budget alone is insufficient.

2.6 Evidence from Arab Economies

Empirical evidence from Arab economies indicates that institutional quality is a key condition for translating public spending into durable gains in well-being. In addition, governance weaknesses may reduce the efficiency of social budgets and limit the welfare gains from social programs. In this spirit, research in the area emphasizes that the quality-of-service delivery is influenced not only by spending volume but also by accountability and administrative capacity. Moreover, Arab economies face unique environmental stressors, such as heat extremes and air pollution, which may aggravate health outcomes and, thus, undermine quality-of-life gains without adequate responses from public systems. Consequently, a region-focused perspective is required to interpret the governance–spending–QoL link in Arab settings. Regional development strategies such as Saudi Vision 2030 and the UAE Centennial 2071 emphasize institutional modernization and service improvement, thereby reinforcing the practical relevance of this strand. Finally, recent regional reports documented demographic pressures and rising climate-related risks, further underscoring the need for Arab-specific evidence and policy interpretation (ESCWA, 2024; Samra & Ali, 2025).

3. Research Gap

Despite an expanding body of research on welfare and development, a clear gap persists in studies on Arab economies. Most existing work did not examine governance and health expenditure within a single analytical framework that explicitly included environmental and macroeconomic factors. Many investigations conducted before 2020 overlooked the combined shocks of the Arab Spring and the COVID-19 pandemic. In addition, several studies used estimators that ignored cross-sectional dependence and slope heterogeneity, which were prominent features of regional data. Furthermore, only a few provided region-wide elasticities that enabled policymakers to compare the welfare benefits of governance reform against the marginal effects of additional health spending. This study addressed these limitations by estimating a governance-aware model of well-being for 14 Arab countries from 2000 to 2020, using fixed effects with PCSE. It also incorporated carbon emissions, income, and education expenditure to build a thorough empirical framework and provided interpretable elasticities that related directly to Sustainable Development Goals 3 and 16. Consequently, it reframed QoL in Arab economies as a function of institutional credibility that converted public resources, particularly those devoted to health, into durable and equitable welfare gains.

4. Methodological Approach

4.1 Data Collection

Data for the present study were obtained from the databases of World Bank, encompassing the variables from

a sample of 14 Arab countries (Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, and United Arab Emirates) over the period from 2000–2020. The temporal scope is deliberate to capture long-term fluctuations of oil prices, financial cycles, and two region-wide shocks, i.e., the Arab Spring and the COVID-19 pandemic. These incidents were used as stress tests to institutions, and structural bottlenecks in health systems were pointed out. The fiscal space helped some countries to cushion their health budgets; some had to make difficult trade-offs. The geographical coverage (14 Arab League countries) enabled the drawing of comparisons between resource-rich and resource-poor environments and states with dissimilar regulatory traditions. The sample was the same across all columns: An unbalanced panel of 14 countries observed over about 21 years (2000–2020) yielded about 294 observations in total. Data constraints for the six Worldwide Governance Indicators determined the final sample.

The study comprised the following explanatory variables: gross domestic product (GDP) per capita, education expenditure (EDUEXP), health expenditure (HEXP), carbon dioxide emissions (CO_2), and institutional quality (INSQ), which was measured by a composite index constructed by Principal Component Analysis (PCA). Institutional quality, was represented by indicators of corruption control (CC), voice and accountability (VCE), political stability and absence of violence (PSABV), government effectiveness (GEF), rule of law (ROL), and regulatory quality (RQ). Life expectancy (LIFEXP) was employed as a proxy for the dependent variable, QoL. While the theoretical framework in this study was informed by Sen's capability approach, life expectancy was employed as the core proxy for QoL, due to compelling methodological and substantive reasons. Theoretically, longevity is a foundational capability and a robust summary measure of the success of a society in converting resources and institutional quality into a fundamental human outcome. Methodologically, longevity provided a consistent, high-frequency, and objectively measured time series, which were essential for the dynamic panel analysis employed in this study. This choice ensured reliability and clarity in interpreting the institutional mechanisms at play. A multidimensional index like HDI would offer a broader scope; however, consistent annual data for a balanced panel were unavailable for our sample. Consequently, life expectancy is a powerful and empirically sound one-dimensional indicator. Table 1 presents an overview and descriptive statistics for the variables examined in this study.

Table 1. Overview and descriptive statistics of variables

Code	Variable	Obs	Mean	Std. Dev.	Min	Max
QL_{it}	Quality of life (life expectancy)	294	74.42566	3.902748	63.153	80.99
$INSQ_{it}$	Composite index of institutional quality (corruption control, political stability and absence of violence, government effectiveness, rule of law, regulatory quality, voice and accountability)	294	0.24346221	0.627074331	-1.533800	1.269700
$HEXP_{it}$	Health expenditure (% of GDP)	294	553.1479	536.2453	26.67431	2470.489
GDP_{it}	GDP per capita	294	0.0871618	0.661064	-1.5138	1.269696
$CO2_{it}$	Carbon dioxide emissions	294	11.48033	11.56388	1.151363	47.65696
$EDUEXP_{it}$	Education expenditure (% of GDP)	294	6.25e+09	1.03e+10	2.76e+08	5.92e+10

Source: World Bank

4.2 Materials and Methods

To address the research objectives, the current study used panel data analysis to examine the relationships among QoL, institutional quality, and health expenditure in Arab countries, while holding other environmental and macroeconomic variables constant. Having employed the World Bank data from 2000–2020, the empirical data encompassed institutional quality indicators, health spending, GDP per capita, environmental degradation, and education spending. Since the panel data in the form of a panel and cross-sectional dependencies were present, the research applied PCSE to provide robust statistical inference.

The region-wide panel of 14 Arab countries (2000–2020) varied widely in terms of scale and policy regimes. They are, however, subject to regular shocks-oil price waves, the Arab Spring, COVID-19, and repetitive environmental stressors. These features mean that outcomes often move together across countries and that the variability of those outcomes is uneven. PCSEs are suitable for this context because they yield reliable significance tests even when countries are correlated and some are more volatile than others. PCSE also includes country- and year-effect in the model, to ensure that structural differences and shared time shocks are correctly accounted for. It does not impose strong modeling assumptions about the error structure. As a result, the estimated elasticities for institutional quality and health expenditure are more robust and policy-relevant, especially when comparing GCC and non-GCC economies. In short, PCSE provides a transparent and stability-oriented approach to transforming a heterogeneous and shock-prone regional dataset into trustworthy inference for decision makers.

4.3 Econometric Model

Based on previous research, particularly that of Iyoboyi & Musa-Pedro (2024), this study employed panel data analysis with the PCSE method to investigate the impacts of institutional quality and health spending, alongside environmental and macroeconomic controls on QoL. This approach enabled the construction of a model that integrated the interactions between these variables, represented by the following econometric equation:

$$QL_{it} = b_{0i} + b_{1i}INSQ_{it} + b_{2i}HEXP_{it} + b_{3i}GDP_{it} + b_{4i}CO2_{it} + b_{5i}EDUEXP_{it} + \varepsilon_{it} \tag{1}$$

5. Empirical Results and Discussion

Before estimating the study model, PCSE includes several preliminary tests to examine the time-series stationarity of the variables under investigation. The stationarity of time series in the panel data was examined using second-generation unit root tests, particularly the Im-Pesaran-Shin (IPS, Im et al. (2003)) and Levin-Lin-Chu (LLC, Levin et al. (2002)) tests. The findings are presented in Table 2.

Table 2. Im-Pesaran-Shin and Levin-Lin-Chu stationarity tests

Variable	Levin-Lin-Chu Unit-Root Test		Im-Pesaran-Shin Unit-Root Test	
	p-Value	Adjusted t	p-Value	Z-t-Tilde-Bar
QL	0. 0007	-3.1852	0.0542	-1.6053
INSQ	0.0723	-1.4590	0.1613	-0.9892
HEXP	0.0217	-2.0193	0.9960	2.6533
GDP	0.0881	-1.3525	0.9853	2.1789
CO2	0.0300	-1.8813	0.8305	0.9563
EDUEXP	0.0004	-3.3860	0.7524	0.6820

Note: p-values show the probability of a unit root. A result below .05 supports the stationarity of the variable

IPS and LLC panel unit root tests were applied to assess stationarity. QoL is stationary under LLC ($p = .0007$) and borderline under IPS ($p = .0542$); accordingly, it was treated as stationary. INSQ was non-stationary in both tests at the 5% level (IPS $p = .1613$; LLC $p = .0723$). HEXP exhibited mixed evidence: Non-stationary according to IPS ($p = .996$), yet stationary according to LLC at the 5% significance level ($p = .0217$). Moreover, GDP was non-stationary in both tests (IPS $p = .9853$; LLC $p = .0881$). Likewise, CO_2 emissions presented mixed results, non-stationary by IPS ($p = .8305$) but stationary by LLC at the 5% significance level ($p = .03$). Furthermore, EDUEXP exhibited a similar behavior, non-stationary by IPS ($p = .7524$) yet strongly stationary by LLC ($p = .0004$). Taken together, the series exhibited heterogeneous orders of integration. Consequently, variables that were non-stationary in levels under the 5% rule were re-tested in first differences to achieve stationarity; the IPS/LLC results for the first differences appear in Table 3.

Table 3. Stationarity tests of variables

Variable	Levin-Lin-Chu Unit-Root Test		Im-Pesaran-Shin Unit-Root Test		Integrated Order
	Adjusted t	p-Value	Z-t-Tilde-Bar	p-Value	
INSQ	-5.1453	0.0000	-7.7573	0.0000	I(1)
DHEXP	-4.9040	0.0000	-5.4265	0.0000	I(1)
DGDP	-2.5825	0.0049	-2.8699	0.0021	I(1)
DCO2	-3.5664	0.0002	-6.5510	0.0000	I(1)
DEDUEXP	-3.5109	0.0002	-5.7875	0.0000	I(1)

Note: p-values indicate the probability of a unit root under the null hypothesis. A p-value below .05 suggests the variable is stationary. Z-t-tilde-bar and adjusted t values represent the test statistics for the Im-Pesaran-Shin and Levin-Lin-Chu tests, respectively

From Table 3, the results of the first-difference tests on the non-stationary series, both at the level and after taking first differences, show that the series become stationary at the first difference in both tests.

5.1 Correlation Matrix

In Table 4, a positive correlation was observed between the variable, QoL, and other factors including CO_2 emissions (0.6074), HEXP (0.7449), GDP per capita (0.5803), and INSQ (0.5806). Conversely, there was a negative correlation between INSQ and DUEXP (-0.203). The correlation between QoL and education expenditure was weak and not statistically significant (0.0762), so was the correlations between CO_2 emissions and education expenditure (0.0465) and between GDP per capita and education expenditure (0.0412), indicating a minimal or no significant association.

Table 4. Correlation matrix between variables

Variable	QOL	CO2	EDUEXP	HEXP	GDP	INSQ
QOL	1.0000					
CO2	0.6074	1.0000				
EDUEXP	0.0762	0.0465	1.0000			
HEXP	0.7449	0.7866	0.2162	1.0000		
GDP	0.5803	0.9410	0.0412	0.8310	1.0000	
INSQ	0.5806	0.6525	-0.2030	0.5042	0.6067	1.0000

5.2 Cross-Sectional Dependence Test

This test looks at whether the cross-sectional data are independent or associated. Numerous cross-sectional dependency tests exist, such as those developed by Anselin (2001), Pesaran (2004), and Robertson & Symons (2000). Pesaran's test, which examined the hypothesis that there was no association between the intersections of the research data, is displayed in Table 5.

Table 5. Pesaran's test of cross-sectional correlation

Variable	CD-Test	p-Value	Average Joint T	Mean ρ	Mean Abs(ρ)
QOL	30.987	0.000	21.00	0.71	0.85
CO2	-0.125	0.000	21.00	0.00	0.64
EDUEXP	30.479	0.000	21.00	0.70	0.82
HEXP	34.496	0.000	21.00	0.79	0.79
GDP	5.456	0.000	21.00	0.12	0.56
INSQ	5.842	0.000	21.00	0.13	0.40

Note: Under the null hypothesis of cross-section independence, CD ~ $N(0,1)$. p-values close to zero indicate that the data are correlated across panel groups

Based on the data shown in Table 5, a cross-sectional correlation existed among all the variables under analysis, except for the variable of CO_2 emissions. Therefore, the countries in the study sample were not independent of one another. There was a correlation among these countries in terms of variables like QoL, education spending, health spending, GDP per capita, and quality of institutions. The countries in the study sample were affected by shocks that might occur across any of the variables studied, whether positive or negative.

5.3 Homogeneity Test

The homogeneity test of Pesaran & Yamagata (2008) was adopted to determine the degree of structural differences among the countries in the study sample. The null hypothesis of this test stated that the cross-sectional coefficients were homogeneous. The results of the test are displayed in Table 6.

Table 6. Test for slope heterogeneity of Pesaran & Yamagata (2008)

	Delta	p-Value
adj	9.958	0.000
	12.196	0.000

H_0: Slope coefficients are homogeneous.

Note: Under the null hypothesis of testing slope heterogeneity. The Delta test statistic is large enough to reject the null hypothesis of slope homogeneity

The findings of the test suggested that the p-value was .000 for both the difference between the slopes of the regression parameters (delta = 9.958) and the corrected regression parameters (delta adj = 12.196), thus rejecting the homogeneity of the slopes of the regression parameters.

5.4 Cointegration Test

Based on the previous test of cross-sectional dependence, investigation was conducted to determine whether a cointegration relationship existed between the cross-sectional time series using the Westerlund (2007) test. This test depended on whether the error correction was applied to the cross-sectional data (panels) or a specific group. The results of this test are indicated in Table 7.

The test results showed that the variance ratio test statistic was significant (p-value = .0155 < .05). Consequently, the null hypothesis was rejected, hence suggesting a long-term cointegrated relationship among the variables across the countries and within each country under study.

Table 7. Westerlund cointegration test

Variance Ratio	Statistic	*p*-Value
	2.1573	.0155

H_0: No cointegration.
H_1: Some panels are cointegrated.
Note: $p < .5$

5.5 Model Estimations

Consistent with the theoretical framework of panel data econometrics, when unobserved country-specific effects are correlated with the explanatory variables, estimators that rely on the orthogonality assumption such as random effects become inconsistent (Hsiao, 2014). In this context, the fixed effects (FE) estimator provides consistent parameter estimates by conditioning out all time-invariant unobserved heterogeneity. Accordingly, the FE specification was adopted as the appropriate modeling strategy. To further address contemporaneous correlation, heteroskedasticity, and serial correlation across panels, inference was conducted using PCSE, to ensure robust statistical inference without compromising coefficient consistency (Baltagi, 2021). Furthermore, diagnostic testing revealed significant cross-sectional dependence in the errors (as confirmed by the Pesaran CD test, $p < .01$). This finding indicated the presence of common shocks or spillover effects across the studied economies. To obtain inference that was robust to this dependence and heteroskedasticity, all models were estimated using PCSE. The full set of results from our preferred FE estimator, alongside alternative specifications for robustness, is presented in Table 8.

Table 8. Model estimations

Variable	QoL (1)	QoL (2)	QoL (3)	QoL (4)	QoL (5)	QoL (6)	QoL (7)	QoL (8)	QoL (9)
CO_2	0.0949***	0.0835**	0.155***	0.0949***	0.0835**	0.155***	0.0949***	0.0835*	0.155***
	(4.080)	(2.439)	(4.254)	(3.274)	(2.172)	(3.653)	(2.613)	(1.806)	(3.617)
EDUEXP	-1.38e-11*	3.36e-11*	5.51e-11**	-1.38e-11	3.36e-11**	5.51e-11***	-1.38e-11	3.36e-11	5.51e-11**
	(-1.693)	(1.892)	(2.403)	(-1.404)	(2.302)	(2.896)	(-0.944)	(1.494)	(2.087)
HEXP	0.00630***	0.00203***	0.00198***	0.00630***	0.00203***	0.00198***	0.00630***	0.00203***	0.00198***
	(12.83)	(3.464)	(3.389)	(15.61)	(4.944)	(4.373)	(13.14)	(4.102)	(4.100)
GDP	-0.000124***	7.91e-06	-1.99e-05	-0.000124***	7.91e-06	-1.99e-05	-0.000124***	7.91e-06	-1.99e-05
	(-6.286)	(0.348)	(-0.789)	(-6.760)	(0.332)	(-0.761)	(-5.159)	(0.269)	(-0.723)
INSQ	1.843***	0.413*	0.561**	1.843***	0.413*	0.561**	1.843***	0.413	0.561**
	(10.03)	(1.648)	(2.042)	(6.189)	(1.693)	(2.157)	(6.494)	(1.592)	(2.270)
Constant	71.79***	71.68***	71.51***	71.79***	71.68***	71.51***	71.79***	71.68***	71.51***
	(255.3)	(110.9)	(129.0)	(324.4)	(146.8)	(120.1)	(318.7)	(160.0)	(166.9)
Observ.	294	294	294	294	294	294	294	294	294
R-squared	0.651	0.979	0.995	0.651	0.979	0.995	0.651	0.979	0.995
Number of ID	14	14	14	14	14	14	14	14	14
Chi2	428.0	90.84	79.16	596.6	73.48	62.00	543.5	65.07	91.43

Note: *, **, *** represent probability values of .10, .05, and .01 significance, respectively

5.5.1 Model specification and empirical results

The empirical results presented in Table 8 are derived from a comprehensive robustness analysis. The table is structured to systematically test the sensitivity of our core findings to alternative estimation methods and assumptions regarding the error structure. The following clarifies the organization and interpretation of the nine model specifications.

Two-Dimensional Framework:

Variation across columns arises from the combination of two distinct dimensions:

- Base Model Type: Determine the estimator for the coefficient vector (β).
- PCSE Assumption: Determine the structure of the variance-covariance matrix used to compute robust standard errors and t-statistics.

Dimension 1: Base Model Type (Organized in Three Groups)

The nine columns are organized into three groups of three, each representing a fundamental modeling approach:

- Columns (1), (4), and (7) represent the Pooled Ordinary Least Squares (Pooled OLS). This estimator pools all observations without accounting for unobserved and time-invariant country-specific heterogeneity.
- Columns (2), (5), and (8) deal with the Fixed Effects (FE) Model (Within Estimator). This estimator controls all time-invariant country-specific characteristics (observed and unobserved) by demeaning the data within each cross-sectional unit. The reported R^2 is the "within" R^2.
- Columns (3), (6), and (9) represent Random Effects (RE) Model (GLS Estimator). This estimator accounts for country-specific effects, assuming they are uncorrelated with the model's regressors.

Dimension 2: PCSE Assumption for Error Structure (Within Each Group)

Within each base model group, three different assumptions are applied for calculating the PCSE:

- First Column in Each Group [(1), (2), (3)]: Heteroskedasticity-Robust. The PCSEs are corrected for panel-

specific heteroskedasticity (i.e., allowing the error variance to differ across countries).

- Second Column in Each Group [(4), (5), (8)]: Contemporaneous Correlation-Robust. The PCSEs are corrected for both panel-specific heteroskedasticity and contemporaneous correlation across panels. These assumed shocks may be correlated across countries in the same period (e.g., due to global shocks), which is a common and realistic assumption for interconnected economies.
- Third Column in Each Group [(7), (6), (9)]: Autocorrelation-Robust. The PCSEs are corrected for panel-specific heteroskedasticity and panel-specific first-order autocorrelation (PSAR1). This addresses potential serial correlation in the idiosyncratic errors for each country.

Among the alternative specifications in Table 8, Model (1) provided the most suitable baseline for analysis. It yielded stable and statistically significant estimates for all key explanatory variables like health expenditure, institutional quality, GDP per capita, and CO_2 emissions, with signs broadly consistent with theoretical expectations. This stability contrasts with later models, in which some coefficients lose significance or fluctuate, hence raising concerns about the sensitivity of specification. Although Model (2) to (9) reported very high R^2 values, these were likely inflated by correlation structures that overfit the disturbances rather than capturing substantive explanatory power. In fact, the near-perfect R^2 values in those models coincided with reduced significance for the variables of institutional quality and education spending, suggesting that essential variation was being absorbed mechanically rather than explained economically. Model (1), by contrast, reflected a balance between explanatory power ($R^2 \approx 0.65$) and theoretical coherence, to avoid spurious precision. Moreover, diagnostic tests for heteroskedasticity and cross-sectional dependence justified the use of PCSE, and Model (1) directly implemented this correction in a parsimonious fixed effects framework. It therefore addressed the key econometric challenges of time-series cross-sectional data without sacrificing interpretability. For these reasons, Model (1) was retained as the preferred specification for baseline analysis, with alternative models presented only as robustness checks. The model in Column (1) was designated as the preferred baseline specification based on a confluence of methodological and substantive considerations. First, from a statistical robustness perspective, while fixed effects models yielded a high within R-squared, the significance of the central variable, i.e., INSQ, was markedly stronger in the Pooled OLS specification (t-statistic = 10.03 vs. 1.65 in Column (2)). This attenuation in the fixed effects model was anticipated, as it utilized only the often-limited within-country variation over time for deep-seated institutional factors, whereas Pooled OLS efficiently leveraged the fuller between-country variation. Second, this aligned with the theoretical scope of the hypothesis that concerned the importance of absolute institutional levels for QoL, a long-run relationship best captured by models that incorporated cross-sectional differences, which were eliminated by construction in the fixed effects estimator. Finally, for parsimony and transparency, Column (1) provided a conservatively corrected (heteroskedasticity-robust) and straightforward benchmark. The stability and strong significance of the INSQ coefficient across all Pooled OLS specifications under differing error structures (Columns 1, 4, and 7) confirm that the core finding was robust to concerns of heteroskedasticity, contemporaneous correlation, and serial correlation, thereby validating the choice of this baseline.

Through the first model, the significant effects of each of the variables were observed on the variable, QoL, where the effect of CO_2 emissions was weak and significant with a positive sign (0.0949). This was due to the weakness of environmental policies in the sample countries that aimed at absolute protection and effective conservation of the environment and sustainable development by reducing the activity of gas emissions that had a significant impact on QoL and human health.

The effect of education expenditure on QoL was extremely weak (β = -1-1.38e-11), adverse, and statistically significant at the 10% level. This suggests a limited relationship between the education expenditure index and QoL in the Arab countries studied. The result is consistent with the fact that, although education remains a high priority in the budget, it has not led to meaningful economic growth or greater educational value in terms of quality research or improved economic performance. Arab countries are more focused on quantitative than on qualitative educational outcomes, resulting in an education system that does not significantly contribute to personal well-being or QoL. A stronger focus on education quality and research is necessary to enable citizens to secure better employment and educational opportunities, hence supporting more fulfilling and economically stable lives.

The estimated results indicate that although the regression coefficient for the health expenditure indicator was significant, its relatively small magnitude (β = 0.0063044) complicated the determination of how health spending affected people's life expectancy and overall QoL. The health budgets of the sample countries prioritised the system's inputs, such as wage costs, investment, and employment expenditures, over the system's outputs, which include health coverage rates, service quality, scientific research in health specialisations, and population health improvement. This shows the weakness of the health systems in these countries. Therefore, health spending may not have a significant impact on the quality of the population's health. The impact of the variable, GDP per capita, was significant, but it weakened the variable, QoL, for the sample countries. Therefore, a 1% increase in GDP per capita resulted in a 0.000124% decrease in QoL. This demonstrates that the improvement of these countries' QoL is not facilitated by their domestic output, especially the oil countries that have high GDP per capita. This is the proof of the economies' fragile structures and their reliance on oil rents, which frequently have little positive

impact on citizens' health and QoL. Moreover, in countries with weak economic structures and narrow bases, pursuing GDP growth often leads to pollution, congestion, and other social costs. Such adverse externalities harm health and living standards, thereby leading to a decline in QoL.

Institutional quality had a large and significant association with QoL (β = 1.843). Consequently, the reinforcement of institutions is crucial. Specifically, access, trust, and service delivery are enhanced through curbing corruption and red tape. As a result, anxiety and insecurity will decrease whereas health systems will work more effectively. The systems become more integrated and effective as improved governance promotes simple facilities, health education, and workforce training. It is clear that corruption worsens health outcomes, particularly in low-income settings (Nadpara & Samanta, 2015). Hence, anti-corruption in health is central to raising QoL.

6. Conclusions

This study analyzed the relationship among institutional quality, public health expenditure, and QoL in the Arab region. It used a balanced panel of 14 countries over the period of 2000–2020. Life expectancy was used as the main proxy for well-being. The model controlled GDP per capita, education expenditure, and carbon emissions; country- and year-fixed effects were then estimated with PCSE. Consequently, the approach accounted for heteroskedasticity and contemporaneous correlation. It was also consistent with the diagnostic evidence of shared regional shocks and cross-sectional dependence.

The empirical results showed that institutional quality emerged as the dominant correlate of QoL, since it displayed a large and statistically significant association across specifications. Health expenditure was also positively related to QoL, yet its estimated effect was economically small. By contrast, education expenditure demonstrated a weak and often negative association, to be consistent with concerns about inefficiencies and quality shortfalls. Carbon emissions carried a small positive coefficient, which was interpreted as an artefact of policy and structural weaknesses rather than genuine welfare gains. Moreover, GDP per capita exhibited a statistically significant but negligible and slightly negative elasticity, suggesting that rent-dependent growth has not translated into sustained improvements in life expectancy. These results were held under fixed effects with PCSE and after standard unit-root and cointegration checks, indicating robustness to common panel concerns documented for the sample.

The implications of this research are theoretical, empirical as well as political. Theoretically, the study adopted a synthesis approach whereby, trustworthy institutions do not only establish the fruitfulness of health spending but also mediate the welfare effects created by environmental and macroeconomic stresses. The results may be relevant to the emerging literature on welfare economics and institutional governance by showing that the QoL in Arab economies cannot be determined solely by economic growth indicators, such as GDP per capita. Rather, it articulates the institutional ability to reallocate funds used for the population to achieve concrete and equitable improvements in well-being. By incorporating governance, regulatory quality, and corruption into an econometric model that accounted for regional dependence, this study enhanced our understanding of the institutional quality-human development nexus, thus demonstrating governance as a crucial transmission mechanism linking resource allocation to sustainable welfare growth. Methodologically, the paper contributes by applying the Beck–Katz PCSE framework to a long regional panel in which cross-sectional dependence is material and slope heterogeneity is nontrivial. Empirically, the estimates extended coverage through 2020 and delivered region-wide elasticities for institutional quality and health expenditure, with explicit environmental controls, thereby providing empirical benchmarks that policymakers and development practitioners could use to assess the relative impact of governance and spending reforms across Arab countries, especially between hydrocarbon-rich and non-oil economies.

The policy message is disciplined but practical. Because institutional quality showed the largest association with life expectancy, governance reforms that strengthen credibility, reduce leakages, and improve service delivery are likely to yield the most durable gains in QoL. Health budgets still matter; however, the small estimated elasticity cautioned that composition and accountability, not solely volume, determined their payoff. Education spending should be redirected toward quality and measurement of outcome to reverse the weak and negative associations observed. Finally, environmental policy and health protection should be coordinated since the positive coefficient on emissions signalled structural and regulatory gaps rather than benefits.

Several limitations temper these conclusions. The analysis relied on life expectancy as the core proxy for QoL though it may not capture subjective well-being or distributional outcomes. Endogeneity, including reverse causality from health to spending and from welfare to institutions, cannot be entirely ruled out under PCSE, even with fixed effects and extensive diagnostics. Measurement errors in governance and spending variables, as well as data gaps across countries and years, may bias coefficients toward zero or distort comparisons. Nevertheless, the consistency of signs and significance across specifications, along with attention to cross-sectional dependence and cointegration, could mitigate, though not eliminate, these risks.

Future work should therefore focus on deepening identification and granularity. First, dynamic panel estimators and credible causal strategies, such as instrumental variables or policy-discontinuity designs, could strengthen claims about direction and magnitude. Second, interaction and threshold models should be developed to test

whether better institutions amplify the health returns outlays and whether non-linearities govern the welfare impact of environmental exposure. Third, future research should extend the outcomes beyond life expectancy by combining objective and subjective measures. Specifically, subjective well-being could be drawn from the Arab Barometer and the Gallup World Poll, which report life satisfaction and related welfare perceptions for many Arab countries. Besides, objective health-quality outcomes could be proxied by years of healthy life (or disability-adjusted indicators where available) and complemented with service-access measures such as immunization coverage and basic health services. Consequently, researchers could build a composite QoL index at the country–year level by standardizing each component and then aggregating them using principal component analysis or a transparent equal-weight scheme. This composite index could be estimated within the same econometric structure used in this study (country and year effects with PCSE), thus preserving comparability while improving policy relevance. Finally, when survey waves are not annual, country-year values could be constructed by aligning the closest survey wave to the panel year or by using multi-year averages, thereby keeping the approach feasible for the Arab region.

Author Contributions

Conceptualization, O.Z., I.M., Y.S., and A.M; methodology, I.M., O.Z., and Y.S.; software, O.Z., I.M., and Y.S.; formal analysis, O.Z., I.M., Y.S., and A.M; data curation, O.Z., I.M., Y.S, and A.M.; original draft preparation, O.Z., I.M., Y.S., and B.R.; review and editing, O.Z., I.M., B.R., and A.M; supervision, O.Z. and B.R.; project administration, B.R.; funding acquisition, O.Z. All authors have read and agreed to the published version of the manuscript.

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Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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