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The Impact of Population Aging on Government Healthcare Expenditure: Evidence from Sri Lanka (1960–2023)

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Abstract

Sri Lanka's publicly financed healthcare system faces growing fiscal pressure as the share of the older population rises faster, but country-specific long-run evidence on the size of this fiscal pressure remains limited. This study examines the long-run relationship between population aging and government healthcare expenditure in Sri Lanka using annual time series data from 1960 to 2023. The main objective of this study is to estimate the elasticity of government healthcare expenditure with respect to the share of the population aged 65 and above, life expectancy at birth, and Gross Domestic Product (GDP) per capita. The Autoregressive Distributed Lag (ARDL) cointegration approach is applied to investigate whether these variables significantly impact government healthcare expenditure as a percentage of GDP. The ARDL Bound Test confirms a long-run equilibrium among the variables. Results show that a one percent rise in the share of the population aged 65 and above increases government healthcare expenditure by 0.885 percent ($p = 0.0416$), confirming fiscal pressure from demographic aging. A one percent increase in life expectancy reduces healthcare expenditure by 4.051 percent ($p = 0.0265$), a result consistent with the compression of morbidity hypothesis where healthier populations require less curative care. GDP per capita shows no significant long-run effect. The error correction term (-0.570) indicates that 57 percent of any deviation from equilibrium is corrected within one year. Diagnostic tests confirm model robustness with no serial correlation, no heteroskedasticity, and stable parameters. The findings of this study have implications for Sri Lanka's free healthcare system. Proactive fiscal planning, expanded insurance coverage, and preventive health programs are needed to reduce the aging-related expenditure pressure while extending healthy life years. Policymakers should focus on vaccination programmes, nutrition initiatives, and chronic disease screening that can reduce curative care costs and improve population health outcomes.

Keywords: Aging Population, ARDL Model, Government Healthcare Expenditure, Life Expectancy, Sri Lanka

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INTRODUCTION

Population aging is one of the major demographic transformations affecting governments internationally. This demographic change creates significant challenges for public finance and healthcare sustainability (Bhandari, 2019). In Sri Lanka, the percentage of the aging population over age 65 was 9.4% in 2015, and 21% is projected for 2045; eventually, it will rise to 35.6% in 2100 (Ariyawansa et al., 2023). These demographic shifts represent a unique challenge for Sri Lanka's free public healthcare system that has delivered universal access financed entirely from government revenue. The dual challenge of sustaining Sri Lanka's free public healthcare model while the older population grows faster than in most South Asian peers is the research problem this study addresses. Without country-specific long-run estimates of how government healthcare expenditure responds to demographic and income variable changes, policymakers have limited information about the size of the fiscal adjustment required.

The importance of the study was based on three considerations. First, Sri Lanka's structural dependence on publicly financed healthcare means that the burden of demographic pressure directly falls on the government finances. Second, according to Sri Lanka's aging speed, it reduces the policy response window. Third, country-specific time series evidence is largely absent for Sri Lanka.

The relationship between population aging and government healthcare expenditure is very important where public finance dominates healthcare systems. Some economic theories show that an aging population increases healthcare demand (Bloom et al., 2010). The elderly population experiences a higher rate of chronic diseases (Khan et al., 2024). They need longer periods of medical care. These factors should logically increase government healthcare expenditure. However, the empirical picture is more complex. The compression of morbidity hypothesis (Fries, 1989) holds that improvements in life expectancy can compress the period of high-cost end-of-life care into a shorter period. It partially offsets the expenditure pressure from sheer population aging.

This study contributes to the literature in three ways. First, it provides Sri Lanka-specific ARDL estimates of the elasticity of government healthcare expenditure with respect to the older population, life expectancy at birth, and per capita income. Second, by including both the elderly share and life expectancy in the same model, it allows a direct assessment of the compression of morbidity hypothesis. Third, it offers policy-relevant evidence for a free healthcare system.

There are relatively few empirical studies that have examined the relationship in the Sri Lankan context. Existing literature has mainly focused on cross-sectional and panel data analyses (Kumara & Samaratunge, 2016; Matthews et al., 2023). The interdependence among the aging population, health outcomes measured by life expectancy, and the economic capacity of people measured by GDP per capita requires a methodology capable of addressing non-stationary endogeneity and long-run equilibrium relationships. The ARDL Bound Test approach effectively addresses these challenges. This study fills the research gaps by investigating the long-run impact of the aging population on government healthcare expenditure in Sri Lanka using annual time series data from 1960 to 2023.

This research addresses three specific research questions. First, does the elderly population have a significant impact on government healthcare expenditure in the long run? Second, what is the relationship between life expectancy and GDP and government healthcare expenditure? Third, how quickly does the healthcare spending system adjust when it deviates from long-run equilibrium? The findings of this research may have important implications for Sri Lankan fiscal sustainability and healthcare planning. Sri Lanka is a developing country in the South Asian region facing an increase in the number of aging populations (Ariyawansa et al., 2023). Understanding the magnitude of the expenditure pressure is needed for resource allocation decisions. The rest of this paper is organized as follows. Section 2 reviews literature on aging and healthcare expenditure. Section 3 describes the research methodology, including data sources and the ARDL method. Section 4 presents empirical results and findings. Section 5 concludes with policy recommendations and study limitations.

LITERATURE REVIEW

Theoretical Perspectives on Aging and Healthcare

Red Herring Hypothesis

The Red Herring Hypothesis was introduced by Zweifel et al. (1999). They argued that rather than age, proximity to death was the primary determinant of healthcare expenditure. Zweifel et al. (1999) studied the relationship between healthcare expenditure and age. The researchers used longitudinal data on healthcare expenditures in the eight quarters of the life of individuals who died in Switzerland in 1983 - 1992. They found that healthcare expenditure is determined by remaining lifetime rather than calendar age. The positive relationship between healthcare expenditure and age in cross-sectional data is caused by the simple fact that at age 80, there are more people alive in their final two years than at the age of 65. The minimal influence of age on healthcare expenditure shows that population aging contributes less to healthcare expenditure. This hypothesis challenges the theory that aging populations ultimately lead to rising healthcare expenditure. Researchers stated that expenditures are often higher in the final years of life no matter of chronological age (Gerdtham, 1993; Zweifel et al., 2004). Furthermore, some studies have found that growth in longevity leads to increased demand for medical care (Breyer et al., 2010). That demand complicates the relationship described by the Red Herring Hypothesis.

Steepening Hypothesis

Steepening Hypothesis challenges the Red Herring Hypothesis. It posits that healthcare cost increases disproportionately for older age groups over time (Gregersen, 2014). He found evidence of steepening even when controlling for mortality-related expenditure in Norway. The researcher used Norwegian somatic hospital data from 1998 to 2009. Also, the researcher found that there was an increase in expenditures for 0 years old age group over time. This suggests age-related factors such as different age groups contribute significantly to rising healthcare expenditure.

Compression of Morbidity Hypothesis

The compression of morbidity hypothesis (Fries, 1989) suggests that delaying the onset of chronic illness and disabilities shortens the duration of morbidity just before death, which in turn lowers lifetime healthcare expenses. The hypothesis implies a negative relationship between gains in healthy life expectancy and healthcare expenditure. The hypothesis holds empirical significance for Sri Lanka, as recent improvements in life expectancy have been accompanied by public investments in preventive care which the framework suggests should partially offset the cost pressures associated with aging.

Demographic Transition Theory

Demographic Transition Theory explains the historical shift of population from elevated birth and death rates to reduced birth and death rates as societies become more modern. The transition proceeds in distinct phases where a decrease in mortality comes before a reduction in fertility; the lag between these two creates a prolonged period in which the proportion of older adults increases. Sri Lanka is at an advanced phase of this transition. Life expectancy has aligned with high-income standards, and fertility rates have dropped below the replacement level. The theory suggests a structural and ongoing rise in the demand for healthcare services for the elderly as the transition progresses, offering a theoretical basis for the positive long-run relationship between elderly share and government healthcare expenditure that this study examines.

Wealth Flow Theory

The Wealth Flow Theory developed by (Caldwell, 1976) argues that the net

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intergenerational wealth flow direction changes with social modernization. In pre-transition societies, children generate net economic advantage for parents, while in modernized societies parents bear net economic cost for children. The reversal undermines the traditional family-based support system for the elderly, which typically covered elder care expenses, transferring that financial burden to the government. In a country such as Sri Lanka, where free public healthcare absorbs much of the externalized cost. Wealth Flow Theory predicts an increasing fiscal limitation as the percentage of elderly individuals rises. The theory thereby complements Demographic Transition Theory in explaining why public expenditure responds positively to the elderly share.

Empirical Evidence from Different Countries

Southeast Asian nations are undergoing rapid demographic transition impacting their healthcare expenditure. Baharin & Saad (2018) investigate the connection between aging and healthcare spending in Malaysia, Indonesia, and Thailand using the ARDL model for their analysis. A notable long-term effect of aging on healthcare spending was observed in Malaysia and Indonesia. The relationship was insignificant in Thailand because private healthcare providers dominate the Thai market. These results indicate that affordability and private sector factors influence how aging affects healthcare expenditure.

China's rapid economic development has been matched by a notable demographic change as an increasing aging population is putting strain on the healthcare system. Li et al. (2020) investigate age-related healthcare expenditure in Beijing to explore inequalities across different age categories. Their research indicates that healthcare expenditure for people aged 65 and above was 7.25 times greater than that for individuals under 25. It highlights the challenge of caring for elderly people. This study also emphasized the role of policy interventions in the healthcare sector. For example, access to healthcare services and addressing environmental factors can reduce the cost associated with aging.

In India, the aging population is a major contributor to healthcare costs. It is worsened by rapid urban growth and environmental issues. Mohapatra et al. (2024) investigated the impact of population aging on healthcare expenditure in India. A significant long-term connection was discovered between aging and healthcare expenditure, with income and urbanization as extra factors.

Amin et al. (2022) examined the relationship between increasing diversity and an aging population and healthcare expenditure in the United

States. The scholars researched to examine the direct effects of diversity and the aging population on healthcare spending. The researchers used the Bayesian Vector Autoregression Model, impulse response analysis, and variance decomposition techniques in their study to analyze the effects of the data over the 1990 - 2018 period in the United States. They identified that diversity and aging population variables are more persistent with healthcare expenditures in the United States. Moreover, they concluded that an increase in the aging population and diversity will rely on the long-term healthcare facility.

Hyun et al. (2016) conducted research on Korea's rapid population aging as a major factor in increased healthcare expenditure. They used a Heckman sample selection model and a probit regression model to examine the likelihood of healthcare expenditure, employing the Mills ratio to account for the sample selection effect of deceased individuals and survivors aged 20 and above, verified by the National Health Insurance Service in 2010. The scholar stated that when the time-to-death variable is controlled for as an explanatory variable, healthcare expenditure decreases as a function of age. However, healthcare expenditure during the terminal year increased as a function of time to death. According to these findings, they concluded that the increased number of the elderly population due to aging does not increase the healthcare expenditure in the Republic of Korea.

Methodological Approaches in Population Aging Studies

When studying healthcare expenditure, researchers used a variety of methodologies to identify the complexity and variety of its determinants. Techniques like time series, cross-sectional, and panel data analysis are the most used in this research field. Each one of these techniques has its own ability to address specific research questions.

Time series analysis is more useful when examining trends over long periods of time. This method allows researchers to explore the evolution of healthcare expenditure and its determinants such as demographic shifts, economic growth, and policy changes over time.

Mohapatra et al. (2024) used the Autoregressive Distributed Lag (ARDL) model to investigate the connection between demographic aging and healthcare in India between 1981 and 2018. The major reasons for choosing the ARDL technique are its ability to handle small sample sizes and its ability to identify the short-run and long-run relationships. These abilities are valuable when research about impact of aging on healthcare expenditure.

Time series analysis also facilitates the analysis of causality. Boz and Ozsarı

(2020) employed the Toda-Yamamoto causality test in Turkey to examine the causality between aging, fertility, life expectancy, and healthcare expenditure. They used annual data from 1975 to 2016 in their study and identified one-way causality from aging to healthcare expenditures. These findings show how time series techniques are suitable for age and healthcare expenditure-related research.

Cross-sectional analysis examines data from multiple units at a single point in time. This technique is mostly used to compare healthcare expenditure patterns within contexts. This technique is good for examining how structural and systematic differences impact healthcare expenditure. For example, Santos et al. (2023) conducted a worldwide cross-sectional study including 188 countries to examine the efficiency of healthcare systems. Researchers used age-adjusted healthcare expenditures and demographic variables as proxies for variation in age structure across countries. This analysis identified the major inefficiencies and found how demographic factors influence healthcare efficiency globally.

Lakshmana (2013) employed cross-sectional methods to analyze the association between dependency ratios and healthcare expenditure in South Indian states. The researcher compared different demographic structures. He stated that a higher proportion of dependent populations has a positive impact on healthcare spending.

Panel data analysis has the strength of a combination of cross-sectional and time series methods. This method allows researchers to track multiple units over a certain period. Panel data analysis is most suitable for examining healthcare expenditure at individual-level variation and temporal dynamics.

Borrescio-Higa and Valenzuela (2021) utilized panel data to examine how education influences the impact of aging on healthcare expenditure in Latin America. They used a fixed effects model and revealed that higher educational achievements reduce the financial pressure associated with aging.

Panel data models handle the issues of omitted variable bias by accounting for unobserved differences among units. Li et al. (2020) used a fixed effects model to analyze age-specific healthcare expenditure in Beijing. By controlling unit-specific characteristics, this method is able to provide robust evidence of how aging impacts healthcare demands.

Linking the Reviewed Theories to Empirical Model

The empirical model outlined in Section 3 is guided by the theoretical viewpoints discussed earlier. The Red Herring Hypothesis initially encourages employing a dynamic ARDL model by incorporating lags of all variables; the model reflects the proximity to death pattern in healthcare expenses via its lag structure instead of limiting focus to current age effects. Secondly, the compression of morbidity hypothesis predicts a negative coefficient for life expectancy at birth in the long-run equation. A prediction that the empirical results in section 4 validate. Third, the combination of Demographic Transition Theory and Wealth Flow Theory explains the anticipated positive coefficient for the elderly population share. As Sri Lanka completes its demographic transition and interchangeable wealth flow reverses, the cost of elderly care shifts into public expenditure. These linkages offer a structural interpretation of the elasticities estimated in Section 4.

RESEARCH METHODOLOGY

Data Source and Variables

Annual time series data on government healthcare expenditure (as a percentage of GDP), the population aged 65 and above (as a percentage of the total population), life expectancy at birth, and gross domestic product (GDP) per capita for Sri Lanka were compiled for the period 1960 to 2023, yielding 64 annual observations. Government healthcare expenditure as a percentage of GDP data were obtained from the Central Bank of Sri Lanka annual reports. The 2020 observation was missing due to COVID-19-related reporting delays. It was estimated using linear interpolation.

The percentage of population aged 65 and above was collected from the World Bank World Development Indicators database. This variable directly measures the elderly population in society. This variable captures the demand side pressure on healthcare systems from an aging population. Life expectancy at birth in years was also collected from the World Bank World Development Indicators database. GDP per capita, measured in current US dollars collected from the World Bank World Development Indicators database. This variable controls for the income effect on healthcare expenditure.

Autoregressive Distributed Lag Model

The Autoregressive Distributed Lag (ARDL) Model is a robust econometric model utilized to examine the relationship between time series data. The model simultaneously provides both short-run and long-run relationships (Kripfganz & Schneider, 2023). This flexibility accounts for its widespread use in areas like health economics, financial markets, and environmental research.

One major advantage of the ARDL model is its ability to handle variables with a mix of I (0) and I (1) integration orders (Pesaran, 2008). Traditional cointegration methods such as Engle-

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Granger and Johansen-Juselius require all variables to be integrated at the same order (Jalil & Rao, 2019), which limits their use when the data exhibit mixed integration orders. The ARDL model removes this restriction.

The ARDL model also guarantees consistent estimates of long-run coefficients. These estimates follow an asymptotic normal distribution (Pesaran, 2008). This makes statistical inference more straightforward compared to other cointegration techniques. Moreover, the ARDL model allows researchers to assign different lag structures in each variable that provide flexibility in modelling dynamic relationships (Jalil & Rao, 2019).

Model Specification and Theoretical Framework

This study investigates the long-run relationship between government healthcare expenditure and an aging population using the ARDL cointegration method. The dependent variable measures government healthcare expenditure as a percentage of GDP. It exhibits the fiscal burden of healthcare relative to economic capacity. There are independent variables capturing key factors of aging and economic development: the percentage of the population aged 65 and above, life expectancy at birth, and GDP per capita.

All variables were converted into natural logarithms before estimation. This transformation stabilizes variance and diminishes heteroskedasticity in the data while permitting the interpretation of coefficients as elasticities.

The theoretical long-run relationship is specified as,

$$\ln(GHE_t) = \beta_0 + \beta_1 \ln(POP65_t) + \beta_2 \ln(LEB_t) + \beta_3 \ln(GDPCAP_t) + \epsilon_t$$

Where,

$\ln(GHE_t)$ = natural log of government health expenditure as % of GDP

$\ln(POP65_t)$ = natural log of population aged 65+ as % of total population

$\ln(LEB_t)$ = natural log of life expectancy at birth in years

$\ln(GDPCAP_t)$ = natural log of GDP per capita in current US dollars

ϵ_t = error term

The ARDL specification

$$\begin{aligned}\Delta \ln(GHE_t) = {} & \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta \ln(GHE_{t-i}) + \sum_{j=0}^{q_1} \beta_j \Delta \ln(POP65_{t-j}) + \sum_{k=0}^{q_2} \gamma_k \Delta \ln(LEB_{t-k}) \\ & + \sum_{m=0}^{q_3} \delta_m \Delta \ln(GDPCAP_{t-m}) + \theta_1 \ln(GHE_{t-1}) + \theta_2 \ln(POP65_{t-1}) \\ & + \theta_3 \ln(LEB_{t-1}) + \theta_4 \ln(GDPCAP_{t-1}) + \varepsilon_t\end{aligned}$$

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The Δ symbol exhibits first differences. The p, q1, q2, q3 exhibit lag orders according to the used information criteria. The θ coefficients form the cointegration vector. If these coefficients are jointly significant, that confirms a long-run equilibrium relationship among the variables.

Method of Analyzing Data

Unit Root Testing

Before implementing the ARDL model, the integration order of each variable was evaluated using unit root tests. The Augmented Dickey-Fuller (ADF) Test along with the Phillips-Perron (PP) test was conducted on all variables both at levels and at the first differences.

ARDL model requires no variable integrated of order 2 or higher (Jalil & Rao, 2019). It allows a mix of stationary variables (integrated of order zero) and non-stationary variables (integrated of order one)

Model Selection Criteria

The selection of the optimal lag length is an important step in modelling the ARDL framework. Selecting the optimal lag length ensures the model accurately captures both short-run and long-run dynamics without overfitting the model. In this study, the Schwarz Criterion (SC) was employed to find the optimal lag length. The Schwarz Criterion is very useful in cases where the sample size is relatively small. It applies a more rigorous penalty for model complexity compared to other criteria such as the Akaike Information Criterion (AIC). This approach ensures that only the most statistically relevant lags are included in the final model.

Bound Test for Cointegration

The estimated ARDL model generates an F statistic and a t-statistic to assess the null hypothesis of no long-term cointegration relationship between the variables. Critical values for small samples are sourced from (Narayan, 2005). These critical values provide lower I (0) and upper I (1) bounds at conventional significance levels (1%,5%,10%). The null hypothesis is rejected when the computed test statistics exceed the upper bound, confirming a cointegrating relationship among the variables.

Long Run and Error Correction Estimation

When there is a cointegration relationship, long-run coefficients were derived from the normalized cointegration equation. The error correction model was estimated to obtain the adjustment coefficient. A negative and statistically significant error correction term shows the system corrects deviations from equilibrium.

Diagnostic Tests

The robustness of the model is ensured through several diagnostic tests. The Breusch-Godfrey LM Test checked for

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serial correlation in the residuals. The ARCH test assessed whether residuals exhibit autoregressive conditional heteroskedasticity. The Jarque-Bera Test evaluated residual normality. Cumulative Sum (CUSUM) and Cumulative Sum Square (CUSUM Square) tests checked the stability of the model.

RESULTS AND DISCUSSION

Time Series Plots

Figure 1 shows the time series plots over the period of 1960 to 2023. Government healthcare expenditure (LNGHE) shows multiple peaks and troughs across the period. GDP per capita (LNGDPCAP) shows a clear upward trend through most of the sample period. Population aged 65 and above (LNPOP65) shows a smooth upward trend. The life expectancy at birth (LNLEB) shows a consistent upward trend, reflecting steady improvement in population health.

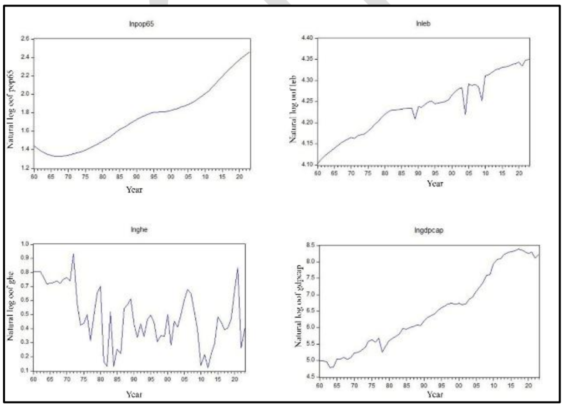

Figure 1. Time series plots

Note. Time series plots show the movement and pattern of each variable over the sample period 1960 to 2023.

Descriptive Statistics

Table 1 shows the key descriptive statistics of variables used in the analysis. The values are expressed in natural logarithms based on 64 annual observations from 1960 to 2023. Government healthcare expenditure as a percentage of GDP (LNGHE) averaged 0.493 over the sample period. It ranged from 0.122 to 0.932. The elderly population (LNPOP65) showed a mean of 1.746. Its values ranged from 1.32 to 2.463. That indicated gradual demographic aging. Life expectancy at birth (LNLEB) should be the most stable pattern. It averaged 4.239 with minimal dispersion (SD=0.067). GDP per capita (LNGDPCAP) displayed the highest variability (SD=1.167), consisting of economic fluctuations experienced over decades.

Distributional diagnostics show near-zero skewness values for government healthcare expenditure and life expectancy variables. The elderly population share exhibits positive skewness (0.479). This indicates concentration in lower values during earlier decades.

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Table 1. Descriptive Statistics

	LNGHE	LNPOP65	LNLEB	LNGDPCAP
Mean	0.492926	1.746005	4.238845	6.475803
Median	0.476215	1.758134	4.236784	6.332794
Maximum	0.932164	2.462892	4.350059	8.389107
Minimum	0.122218	1.328981	4.104328	4.782080
Std. Dev.	0.203851	0.333581	0.067463	1.167333
Skewness	0.047731	0.479449	-0.099162	0.333862
Kurtosis	2.145133	2.217250	2.086960	1.809628
Jarque-Bera	1.973097	4.085823	2.327933	4.967576
Probability	0.372861	0.129651	0.312245	0.083427
Sum	31.54728	111.7444	271.2861	414.4514
Sum Sq. Dev.	2.617968	7.010388	0.286725	85.84797
Observations	64	64	64	64

Note. Descriptive statistics based on authors' calculations using the study dataset

Unit Root Tests

Table 2 shows the p-values of the ADF test and the p-values of the PP test of all variables used in the analysis. These tests used three specifications. They are no intercept and trend, intercept only, and intercept with trend. P-values below 0.05 indicate rejection of the unit root null hypothesis. It confirms the stationarity of the variable. According to these p-values, it indicates that mixed integration order and do not integrate beyond order one. It validates the application of the ARDL model for this analysis.

Table 2. Unit Root Tests (Augmented Dickey-Fuller and Phillips-Perron)

		Level			First Difference		
Variable	Test	None	Intercept	I & T	None	Intercept	I & T
LNGHE	*ADF*	0.0995	0.0048	0.0077	0.0000	0.0000	0.0000
	PP	0.1508	0.0065	0.0082	0.0000	0.0000	0.0000
LNLEB	*ADF*	1.0000	0.7256	0.0002	0.0000	0.0000	0.0000
	PP	1.0000	0.6824	0.0002	0.0000	0.0001	0.0001
LNPOP65	*ADF*	0.9923	0.9983	0.8185	0.3853	0.2875	0.2634
	PP	1.0000	1.0000	0.3865	0.3388	0.0457	0.3143
LNGDPCAP	*ADF*	0.9999	0.9633	0.3899	0.0082	0.0000	0.0000
	PP	0.9999	0.9590	0.3037	0.0000	0.0000	0.0000

Note. Values are p-values from the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests applied to each variable in natural log form. *None* = no intercept or trend; *Intercept* = intercept only; *I & T* = intercept and trend. The null hypothesis is that the series contains a unit root (non-stationary). A p-value below .05 leads to rejection of the null and confirms stationarity.

Model Selection Criteria

Figure 2 shows the values of the Schwarz Information Criterion (SIC) for the 20 leading ARDL specifications calculated with various lag orders. The best model is the one that has the lowest SIC value. SIC penalizes excessive parameterization more heavily than other criteria such as the AIC, which lowers the likelihood of overfitting. The optimal specification based on SIC is ARDL (p, q1, q2, q3) = (1,0,0,0). 'p' represents the lag of the dependent variable (government healthcare expenditure), and q1, q2, q3 are the lags of LNPOP65, LNLEB, and LNGDPCAP. This model includes one lag for the dependent variable (government healthcare expenditure) and no lags for any of the independent variables.

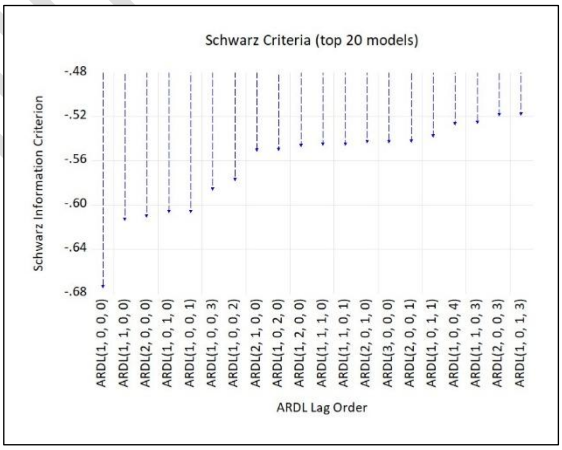

Figure 2. Model Selection Graph

Note. Lag length for the unit root test was selected using the Schwarz Information Criterion (SIC)

Bound Test

Table 3 shows the ARDL bound test for cointegration within the variables. The null hypothesis of no long-run relationship between variables was tested using F-statistics and t-statistics

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approaches. With three independent variables (k=3), the computed F-statistic is 6.033. This F-statistic value exceeds the upper-bound critical value at the 5% significance level. The t-statistic value (-4.867) also exceeds the upper-bound critical values at all significance levels. Both statistics reject the null hypothesis. It indicates that there is a stable long-run equilibrium relationship among government healthcare expenditure, population aging, life expectancy, and GDP per capita.

Table 3. Bound Test

Test statistics	Value	Significance Level	I(0)	I(1)
F-statistic	6.032913	10%	2.72	3.77
		5%	3.23	4.35
		2.5%	3.69	4.89
		1%	4.29	5.61
t-statistic	-4.867103	10%	-2.57	-3.46
		5%	-2.86	-3.78
		2.5%	-3.13	-4.05
		1%	-3.43	-4.37

Note. The null hypothesis states that no long-run relationship exists among the variables. A computed F-statistic exceeding the upper bound critical value indicates cointegration.

Long-Run Coefficient Estimates

Table 4 presents the estimated long-run coefficients derived from the cointegration equation. Given that all variables are log-transformed, the coefficients can be understood as elasticities.

The elderly population (LNPOP65) shows a positive and statistically significant coefficient of 0.885 (t= 2.084, p=0.0416). A one percent rise in the population of aged 65 and above raises government healthcare expenditure by approximately 0.885 percent in the long run. It confirms fiscal pressure from demographic aging.

Life expectancy at birth (LNLEB) shows a negative and statistically significant coefficient of -4.051 (t= -2.277, p = 0.0265). A one percent increase in life expectancy is associated with a 4.051 percent decrease in government healthcare expenditure as a percentage of GDP. This result is consistent with the compression of morbidity hypothesis. Improvements in population health through preventive measures reduce the relative burden of curative healthcare expenditure (Mehta et al., 2017)

GDP per capita (LNGDPCAP) shows an insignificant coefficient of -0.100 (t= -0.747, p = 0.4582). The lack of statistical significance shows that total income growth does not directly change healthcare expenditure as a percentage of GDP in the long run. Two explanations are plausible in the Sri Lankan context. First, because public healthcare in Sri Lanka is largely policy-driven rather than market-driven. Government expenditure responds to political and fiscal priorities more than to direct income elasticities. Second, the elderly share variable (LNPOP65) may already capture much of the structural variation that income would explain given that demographic and economic development have moved together over the sample period.

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Table 4. Long Run Coefficients.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNPOP65	0.88523	0.424821	2.083772	0.0416
LNLEB	-4.050863	1.779088	-2.276933	0.0265
LNGDPCAP	-0.100331	0.134348	-0.746803	0.4582

Note. Long-run coefficients show the lasting effect of independent variables on the dependent variable after adjustment for short-term changes.

Error Correction Model

Table 5 reports the error correction representation of the selected ARDL (1,0,0,0) model. The error correction term (Coineq(-1)) coefficient is -0.570 and statistically significant (t=-5.038, p<0.001). The negative coefficient ensures convergence towards the long-run equilibrium. The magnitude of the error correction term shows that 57% of deviations from equilibrium is corrected within one year.

Table 5. Error Correction Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.553461	1.897691	5.034255	0.000
CointEq(-1)*	-0.569847	0.113113	-5.037841	0.000

Note. ECM estimates short-term changes while correcting deviations from the long-term relationship.

Diagnostic Tests

The Breusch-Godfrey Serial Correlation LM Test examines whether the residuals show autocorrelation. The F-statistic of 0.222 with probability value 0.802 fails to reject the null hypothesis of no serial correlation in residuals. It confirms that the residuals are white noise.

The Breusch-Pagan-Godfrey heteroskedasticity Test has an F-statistic of 2.521 with a probability value of 0.0507 above the 5% significance level. The chi-square statistic (9.330 and 9.232) has probability values of 0.0503 and 0.056 and failed to reject the null hypothesis of homoskedasticity in the residuals. Also, the Autoregressive Conditional Heteroskedasticity (ARCH) Test for heteroskedasticity produce F statistics of 1.773 with a probability value of 0.179. It confirms that the residual variance is stable.

Figure 3 presents the histogram of residuals alongside the descriptive statistics. The mean of the residuals is approximately zero (3.04×10^{-16}), satisfying the classical assumption of zero mean errors. The Jarque-Bera statistic of 2.044 with probability 0.359 failed to reject the null hypothesis that the residuals are normally distributed.

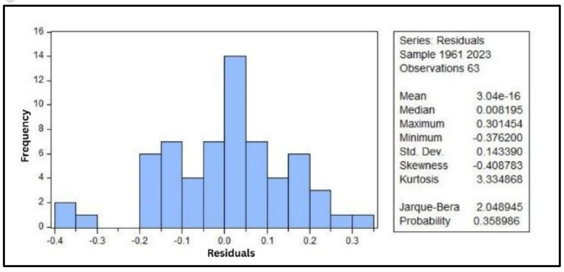

Figure 3. Normality of Residuals

Note. A statistically insignificant p-value indicates normally distributed residuals.

Figure 4 presents cumulative sum (CUSUM) and cumulative sum square (CUSUM square) plots for parameter stability. According to both plots the cumulative sum statistic remains within the 5% significance level through the sample period. It confirms

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that these parameters are stable over time.

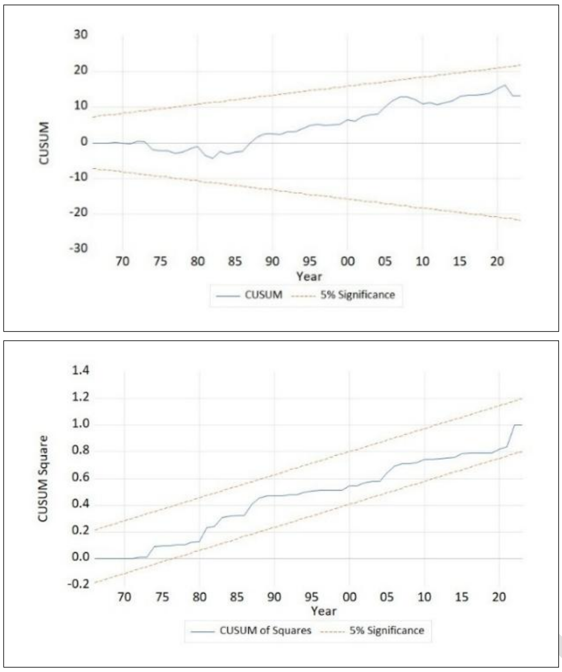

Figure 4 & 5. CUSUM and CUSUM Square Plots

Note. If the plots remain within the 5% critical bounds, the model is considered structurally stable.

DISCUSSION

First, the positive elasticity of 0.885 concerning the elderly proportion reported in Table 4 aligns with the international literature evidence. (Mohapatra et al., 2024) found a similar positive long-run elasticity for India. Baharin and Saad (2018) noted significant aging effects in Malaysia and Indonesia. Consequently, the estimate for Sri Lanka aligns with the regional norm and is not an anomaly.

Second, the negative and significant coefficient of -4.051 for life expectancy at birth (Table 4) is large in absolute value, but the effect's direction aligns with the prediction of the compression of morbidity framework (Fries, 1989). It also aligns with the findings of (Hyun et al., 2016), who show that after controlling for time to death, the apparent impact of age on healthcare expenditure weakens. In the context of Sri Lanka, this indicates that improvements in healthy life years driven by years of public funding in vaccination, maternal and child health, and management of communicable diseases. It has partially offset the financial strain that demographic aging would otherwise impose.

Third, the insignificant -0.100 coefficient on GDP per capita (Table 4) differs from the income elasticity patterns noted in many Organisation for Economic Co-operation and Development (OECD) studies. But it aligns with expectations in a publicly funded healthcare system. Due to policy priorities and fiscal limitations dominating government healthcare spending in Sri Lanka rather than household income. The insignificant coefficient is a signal of the institutional character of the system.

Finally, the -0.570-error correction term shown in Table 5 indicates that 57 percent of any deviation from the long-run equilibrium is corrected within a year. This rapid adjustment strengthens the stability of the estimated relationships and suggests that fiscal impacts of demographic shifts occur over a short enough

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timeline to be significant for medium-term expenditure planning.

CONCLUSION

This research investigated the long-run relationship between population aging and government healthcare expenditure in Sri Lanka using annual time series data from 1960 to 2023. Employing the Autoregressive Distributed Lag Model (ARDL) cointegration method. The study evaluated the responsiveness of government healthcare expenditure with respect to the share of the population aged 65 and above, life expectancy at birth, and gross domestic product per capita. An increasing proportion of the elderly share puts a positive and significant pressure on government healthcare expenditure. It confirms that demographic aging creates a real fiscal burden within Sri Lanka's free public healthcare system. Increased life expectancy is associated with a significant decrease in healthcare expenditure as a share of GDP. It offers empirical evidence for the compression of morbidity hypothesis in South Asian publicly funded healthcare frameworks. GDP per capita shows no significant long-run effect. It aligns with the policy-driven rather than income-driven character of public healthcare provision in Sri Lanka. These findings provide evidence that both the rate of demographic aging and the population's health condition impact the financial trajectory of the healthcare system, and improvements in public health can significantly reduce the spending pressure caused by an aging demographic structure.

These results have three implications for policy and upcoming research. From a policy perspective, maintaining universal free healthcare in the face of rapid population aging will require a purposeful increase in fiscal capacity and a reevaluation of the financing structure. Initiatives like vaccination, nutrition, chronic disease screening, and preventive care can help to reduce aging-related expenditure pressure by extending healthy life expectancy. The study has multiple limitations that need to be acknowledged. The 2020 observation for government healthcare expenditure was interpolated due to delays in reporting caused by the pandemic, and the model considered only three explanatory variables. Urbanization, fertility, and the out-of-pocket share of health financing may act as further determinants that future research could include. Extending the dependent variable to include private and out-of-pocket expenditures, disaggregating the elderly population by single-year age groups to evaluate the steepening hypothesis, and expanding the analysis to a South Asian panel of comparable demographic profiles would together sharpen and generalize the findings of this study.

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