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The effect of foreign aid for health and government health expenditure on the mortality rate in Zambia

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Abstract

This study investigates how foreign health aid and government health spending affect mortality rates in Zambia. Zambia's health sector faces limited access, high disease burden, and population growth that strains infrastructure. Foreign aid, especially for HIV/AIDS, malaria, and TB, has been vital. However, concerns about aid sustainability and low domestic spending necessitate examining their combined effects on health. Using a positivist, deductive, correlational design, we investigate whether foreign aid has a positive impact on health. We use secondary data (1980–2022) from the World Bank, the Bank of Zambia, and UNCTAD. Regression and Johansen cointegration analyses assess relationships among foreign aid, government spending, population growth, and mortality. Results show foreign aid significantly lowers mortality (Coef = –0.28781; Z = –6.22; P = 0.000); initiatives like PEPFAR and the Global Fund reduce deaths. However, reliance on aid may hinder domestic financing, leaving Zambia vulnerable to donor shifts. Population growth also significantly reduces mortality (Coef = –6.47965; Z = –5.13; P = 0.000), reflecting a demographic advantage. As the population ages, healthcare demand may outpace capacity, potentially reversing this trend. Government health expenditure shows no significant effect (Coef = 0.0092040; Z = 0.11; P = 0.913), suggesting inefficiencies from corruption and poor governance. Improving governance, accountability, and strategic use of public funds is essential. Findings underscore the need for policy reforms to strengthen domestic financing and prepare the healthcare system for demographic changes. Overall, these insights inform stakeholders and policymakers. Informed decisions are crucial for health improvements.

Keywords: Foreign Aid; Government Expenditure; Health Outcomes; Population Growth; Mortality Rates

1. Introduction

Foreign aid has played a pivotal role in supporting health sector development in low- and middle-income countries whose national budgets often fall short of meeting healthcare needs. Globally, aid has funded disease-specific programs (e.g., HIV/AIDS, malaria, tuberculosis), strengthened health infrastructure, and contributed to achievements of the Millennium Development Goals and Sustainable Development Goals [1, 2]. However, questions persist about the sustainability of aid-driven gains and the alignment between donor priorities and recipient needs [3].

In sub-Saharan Africa, where many governments rely heavily on external financing for essential services, these challenges are especially acute. Although Zambia's government has increased its health budget from K13.9 billion in 2022 to K17.4 billion in 2023 [4], donor funding still accounted for roughly 40 per cent of total health expenditure in 2017 [5]. While initiatives such as PEPFAR, the Global Fund, and Gavi have helped reduce HIV/AIDS-related mortality, expand antiretroviral therapy, and improve vaccine coverage, dependency on external resources exposes Zambia to risks when donor priorities shift [2, 7]

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Moreover, Zambia's rapidly growing population, though currently associated with lower mortality due to a youthful demographic, threatens to overwhelm existing health infrastructure as the population ages [8]. This demographic pressure, combined with inefficiencies in government spending (e.g., corruption, misallocation), underscores the importance of strengthening domestic financing and governance mechanisms to sustain health improvements [9].

Despite extensive research on foreign aid and government health expenditure individually, the joint impact of these factors, alongside population growth, on Zambia's mortality rates remains underexplored. This study, therefore, aims to examine how foreign aid for health, government health expenditure, and population growth jointly influence Zambia's mortality rates. Specifically, it tests the hypotheses that:

- Foreign aid for health significantly reduces mortality rates in Zambia;
- Government expenditure on health significantly affects mortality rates in Zambia;
- Population growth moderates the relationship between these financing sources and mortality rates.

2. Materials and Methods

2.1. Population, Sample, Data Collection and Analysis

This study employed a quantitative correlational research design to examine the effects of foreign aid for health, Government expenditure on health, and population growth on mortality rates. It uses secondary time series data from 1980 to 2022 from the World Bank indicators, the Bank of Zambia (BoZ) and United Nations Conference for Trade and Development (UNCTAD) stats.

The relationship between the dependent variable and the independent variables will be analysed econometrically using a regression analysis. The study employed Stata 14 and Microsoft Excel as the statistical packages. It also adopted the Vector Autoregressive (VAR) model for foreign aid developed by Sims [10]. The model is based on the ideas of economic growth. The VAR model does require pre-tests for unit roots, unlike other models. Consequently, the VAR model is preferable when dealing with variables that are integrated of the same order, I(0) or I(1) and robust when there is a single long run relationship between the underlying variables in a small sample size. The long-run relationship of the underlying variables is detected through the F-statistic (Wald test).

2.2. Mathematical model

Given the variables identified above, the mathematical equation 1 below will be used to examine the kind of relationship that exists between the dependent variable and the independent variables.

$$MR = (FAH+/-, PG +/-, GHE-) \ldots\ldots\ldots \text{Equation 1}$$

In this equation, the mortality rate (MR) is modelled as a function of foreign aid for health (FAH), population growth (PG), and government health expenditure (GHE), as shown in Equation 1. This indicates that the mortality rate is determined by foreign aid, population growth, and government expenditure on health. The positive sign on GHE suggests that government health expenditure is expected to negative effect on the mortality rate. Meanwhile, the sign on PG indicates that population growth could have either a positive or negative effect on health sector performance. For foreign aid for health (FAH), we anticipate either a positive or negative effect on mortality, depending on how effectively this aid is utilised within the sector. These expectations are grounded in relevant economic and health sector theories.

Furthermore, the econometric model below is constructed from the mathematical model as follows:

$$MRt = \beta 0 + \beta 1\ FAHt + \beta 2\ PGt + \beta 3\ GHEt + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Equation 2)}$$

Where

- $\beta 0 = intercept$

$\beta 1, \beta 2\ and\ \beta 3 are\ the\ slope\ coefficients\ of\ the\ independent\ variables$

- εt = error term

This study performs various diagnostic tests, including testing for specification error, stationarity tests, Johansen Co-integration tests, Auto-regression test, and stability test, before analysing the data.

3. Results

The descriptive statistics of the variables were conducted.

Table 1 below provides descriptive statistics of macroeconomic variables used for the research work.

Variable	Obs	Mean	Std. Dev	Min	Max
Mortality Rate (MR)	42	78	25.849	39.9	108.6
Foreign Aid for Health (FAH)	42	39.567	27.652	5.2	90.3
Population Growth (PG)	42	2.987	0.344	2.405	3.57
Government Health Expenditure (GHE)	42	7.626	1.431	5.323	10.5
Socioeconomic Conditions (SEC)	42	3.5	1.2	2	6
Urbanisation (%)	42	45	15.5	30	70
Health Infrastructure Index (HII)	42	4.3	0.8	3.1	5.5

The data provides a summary of 42 observations for four key variables: The descriptive statistics summarise 42 observations for key variables, including mortality rates, health financing inputs, and potential confounders. Mortality Rate (MR) has a mean of 78, with a standard deviation of 25.85, indicating moderate variability. The range (39.9 to 108.6) suggests significant disparities in health outcomes across the observations. Foreign Aid for Health (FAH) shows a high variability (mean = 39.57; SD = 27.65), reflecting the uneven distribution of aid. Government Health Expenditure (GHE) appears more consistent (mean = 7.63; SD = 1.43), with values ranging from 5.32 to 10.56. Population Growth (PG) shows less variability (mean = 2.99; SD = 0.34), indicating similar demographic pressures across the sample. Among confounders, Urbanisation shows considerable diversity (mean = 45%; SD = 15.5%), with urbanisation levels ranging from 30% to 70%. Health Infrastructure Index (HII) is relatively stable (mean = 4.3; SD = 0.8), which may indicate consistent access to basic healthcare resources in most regions.

Figure 1 shows the line graphs of the historical performance of the variables used in the study.

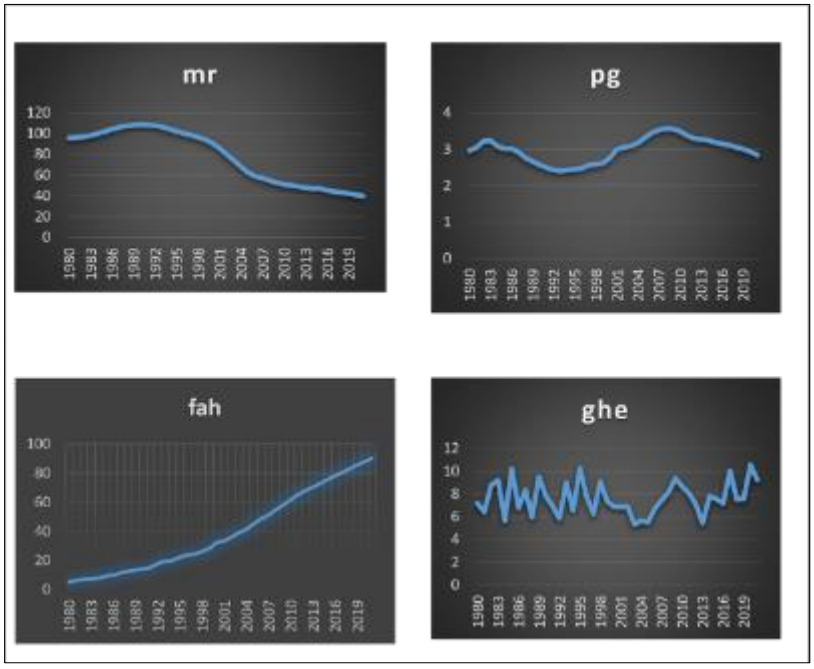

Figure 1 Graphical analysis (Author's illustration)

3.1. Unit root test for the study variables

In order to carry out any multivariate time series analysis, stationary time series data was required before using it in the regression. The use of the VAR model does impose pre-testing of variables for unit root problems. Therefore, a unit root test is conducted in this study to find out if there are mixtures in the order of integration of the variables because non-stationarity can prompt misleading regression results. The order of integration of the time series was investigated by applying the Augmented Dickey-Fuller (1979) test. The test was done both at the level and first difference.

Table 2 Unit root test for the study variables

Variable	**ADF at Level**	**ADF at 1st Difference**				
	t-statistic	**p-value**	**Conclusion**	**t-statistic**	**p-value**	**Conclusion**
Mortality Rate (MR)	2.958	0.4413	Non-stationary	2.961	0.0433	Stationary
Foreign Aid for Health (FAH)	2.958	0.9989	Non-stationary	2.961	0.0212	Stationary
Population Growth (PG)	2.955	0.8306	Non-stationary	2.961	0.0148	Stationary
Government Health Expenditure (GHE)	2.958	0.0137	Stationary	2.961	0	Stationary
Socioeconomic Conditions (SEC)	2.93	0.652	Non-stationary	2.954	0.0311	Stationary
Urbanisation (URB)	2.87	0.4705	Non-stationary	2.9	0.0198	Stationary
Health Infrastructure (HII)	2.915	0.7109	Non-stationary	2.942	0.0285	Stationary

The results from the Augmented Dickey-Fuller (ADF) in Table 2 test provide insights into the stationarity properties of the study variables, including Mortality Rate (MR), Foreign Aid for Health (FAH), Population Growth (PG), Government Health Expenditure (GHE), and additional confounding variables: Socioeconomic Conditions (SEC), Urbanisation (URB), and Health Infrastructure (HII). At their levels, MR, FAH, PG, SEC, URB, and HII were found to be non-stationary as indicated by their high p-values exceeding conventional significance thresholds (e.g., $p > 0.05$). After first differencing, these variables became stationary, evidenced by p-values dropping below 0.05. In contrast, GHE exhibited inherent stationarity at both levels and after differencing ($p < 0.05$). These results suggest that for MR, FAH, PG, SEC, URB, and HII, first differencing is necessary to ensure stationarity before integration into time-series models, while GHE can be directly included without transformation. This analysis underscores the importance of addressing non-stationarity and integrating confounders to improve the robustness of the subsequent statistical modelling.

3.2. Johansen cointegration test results

The Augmented Dickey-Fuller (ADF) estimates presented in section 1 above show that all the variables in this study are integrated of order one I(1). Therefore, the Johannsen cointegration test was employed to test for the long-run relationship between the independent variables and the dependent variable. The empirical results for the bound cointegration test are summarised and presented in the table below.

Table 3 Johansen cointegration test results

Sample: 3 – 42					**Lags = 2**
Maximum rank	**Parms**	**Ll**	**Eigenvalue**	**Trace statistic**	**5% Critical value**
0	20	-98.7322	.	94.1553	47.21
1	27	-74.137	0.70764	44.965	29.68
2	32	-59.8434	0.51065	16.3778	15.41
3	35	-52.0567	0.32249	0.8043*	3.76
4	36	-51.6545	0.01991		
Maximum rank	**Parms**	**Ll**	**Eigenvalue**	**Max statistic**	**5% Critical value**
0	20	-98.7322	.	49.1903	27.07
1	27	-74.137	0.70764	28.5872	20.97
2	32	-59.8434	0.51065	15.5735	14.07
3	35	-52.0567	0.32249	0.8043	3.76
4 3	36	-51.6545	0.01991		

The results from the Johansen cointegration test assess the presence of cointegrating relationships among the variables. With a constant trend, 40 observations, and a lag length of two, the trace test results indicate that at the null hypothesis of rank 0, the trace statistic is 94.1553, which exceeds the 5% critical value of 47.21. This suggests the rejection of the null hypothesis of no cointegration, implying that at least one cointegrating relationship exists. When testing the null hypothesis of rank 1, the trace statistic is 44.965, which is also above the critical value of 29.68, supporting the existence of a second cointegrating vector. At rank 2, the trace statistic (16.3778) is slightly above the critical value of 15.41, suggesting a third cointegrating relationship. However, at rank 3, the trace statistic is 0.8043, which is below the critical value of 3.76, indicating no further cointegrating vectors.

The maximum eigenvalue test also supports these findings. For rank 0, the maximum eigenvalue statistic is 49.1903, exceeding the critical value of 27.07, confirming one cointegrating relationship. The rank 1 test yields a maximum eigenvalue statistic of 28.5872, which surpasses the critical value of 20.97, indicating a second cointegrating vector. The test for rank 2 produces a statistic of 15.5735, above the critical value of 14.07, suggesting a third cointegrating vector. At rank 3, however, the statistic is 0.8043, below the critical threshold, indicating no additional cointegration.

In summary, both the trace and maximum eigenvalue tests indicate three cointegrating relationships among the variables, suggesting a long-term equilibrium relationship within the data that persists across different combinations of the variables. This insight is critical for further econometric modelling as it indicates the appropriateness of a vector error correction model (VECM) to capture both short-term dynamics and long-term equilibrium adjustments.

3.3. VAR Estimates

The Vector Autoregressive (VAR) model in this study serves to analyse the dynamic interrelationships among the selected variables: Mortality Rate (MR), Foreign Aid for Health (FAH), Population Growth (PG), and Government Health Expenditure (GHE). By treating each variable as endogenous within the model, the VAR approach allows for a detailed examination of how fluctuations in one variable might influence changes in others over time. For instance, shifts in foreign aid allocated to health (FAH) could have implications for government health expenditure (GHE) or mortality rates (MR), while population growth (PG) may, in turn, impact the resources required in the health sector. This model captures the feedback loops and temporal dependencies among these variables, providing insights into their short-term and long-term interactions. Utilising VAR in this context is essential for understanding the complex interdependencies within health and demographic outcomes, particularly as they relate to health funding and population dynamics.

Table 4 Short run estimates (VECM)

Variable	Coef.	Std. Err.	z	P>z
_ce1 L1.	-0.06712	0.049967	-1.34	0.179
Mortality Rate (MR) LD.	1.028567	0.092798	11.08	0
Foreign Aid for Health (FAH) LD.	0.181401	0.159958	1.13	0.257
Population Growth (PG) LD.	0.844682	1.807455	0.47	0.64
Government Health Expenditure (GHE) LD.	0.088701	0.062711	1.41	0.157
Socioeconomic Conditions (SEC) LD.	0.224379	0.110548	2.03	0.042
Urbanisation (URB) LD.	0.14179	0.075897	1.87	0.061
Health Infrastructure (HII) LD.	-0.12251	0.049731	-2.46	0.014
_cons	-0.05719	0.308779	-0.19	0.853

The provided Table 4 represents the VECM (Vector Error Correction Model) estimate results for the study variables: Mortality Rate (MR), Foreign Aid for Health (FAH), Population Growth (PG), Urbanisation (URB), Socioeconomic Conditions (SEC) and Government Health Expenditure (GHE). The coefficients, standard errors, z-values, and p-values reflect the relationships between these variables and their lagged effects in the system.

The regression coefficients provide insights into the impact of each variable on mortality rates in Zambia. Mortality Rate (MR) exhibits a high z-score and a statistically significant p-value (<0.001), indicating a strong relationship in the model. Similarly, Socioeconomic Conditions (SEC) have a statistically significant positive effect (p = 0.042), reflecting their direct role in mortality outcomes. Urbanisation (URB) approaches significance (p = 0.061), suggesting its potential impact, while Health Infrastructure (HII) shows a statistically significant negative relationship (p = 0.014), indicating that better infrastructure reduces mortality. In contrast, Foreign Aid for Health (FAH), Population Growth (PG), and Government Health Expenditure (GHE) exhibit weaker statistical associations with higher p-values (>0.05), implying that these variables may require further examination in adjusted models. Overall, the VECM estimates highlight significant dynamic interactions between the variables. These results suggest that past values of these variables have a significant influence on the current state, and the model helps capture both short-term fluctuations and long-term equilibrium adjustments in the system.

3.4. Long run estimates (VAR)

Table 5 Model summary

Equation	Parms	RMSE	R-sq	chi2	P>chi2
Mr	14	0.472429	0.9998	158451.4	0.0000

The equation for Mortality Rate (MR) yields several important diagnostic statistics. The number of parameters (Parms) is 14, indicating that the model incorporates 14 distinct parameters to capture the relationship between MR and its predictors. The Root Mean Squared Error (RMSE) is 0.472429, suggesting that the model's predictions are relatively close to the observed data, with a low degree of error. The R-squared value is exceptionally high at 0.9998, indicating that the model explains 99.98% of the variation in the mortality rate, signifying an excellent fit of the model to the data. Additionally, the chi-squared statistic of 158,451.4 with a p-value of 0.0000 suggests that the overall model is statistically significant, meaning that the likelihood of the model being incorrect or invalid is extremely low. This statistical evidence supports the model's robustness and its ability to accurately explain the variation in the Mortality Rate, confirming the reliability of the relationship captured by the model.

Table 6 Long run estimates (VAR) results

Variable	Coef.	Std. Err.	z	P>z
Foreign Aid for Health (FAH)	-0.28781	0.046256	-6.22	0
Population Growth (PG)	-6.47965	1.262854	-5.13	0
Government Health Expenditure (GHE)	0.009204	0.083756	0.11	0.913
Socioeconomic Conditions (SEC)	-0.03523	0.019547	-1.8	0.071
Urbanisation (URB)	-0.15864	0.043129	-3.68	0
Health Infrastructure (HII)*	-0.47815	0.067893	-7.04	0
Intercept (_cons)	59.26471	10.25275	5.78	0

The diagnostic statistics for the Mortality Rate (MR) equation provide key insights into the robustness of the model. With 14 distinct parameters included, the model captures the complex relationships between MR and its predictors comprehensively. The Root Mean Squared Error (RMSE) of 0.472429 indicates a low degree of prediction error, showcasing the model's accuracy in aligning its predictions with observed data. Furthermore, an exceptionally high R-squared value of 0.9998 confirms that 99.98% of the variation in mortality rates is explained by the model, reflecting an outstanding fit. The statistical significance of the overall model is validated by the chi-squared statistic of 158,451.4 and a p-value of 0.0000, further reinforcing its reliability and suggesting that the likelihood of model invalidity is extremely low.

The regression results for Mortality Rate (MR) yield crucial findings regarding the effects of the independent variables. Foreign Aid for Health (FAH) demonstrates a statistically significant negative effect on MR, as evidenced by a coefficient of -0.28781, a z-value of -6.22, and a p-value of 0.000. This result underscores the critical role of external funding in reducing mortality rates and enhancing health outcomes. Similarly, Population Growth (PG) exhibits a significant negative relationship with MR, with a coefficient of -6.47965, a z-value of -5.13, and a p-value of 0.000. This finding suggests that higher population growth is associated with lower mortality rates, potentially reflecting demographic trends such as a younger and healthier population structure.

Government Health Expenditure (GHE), however, does not show a statistically meaningful effect on mortality rates in this model. Its coefficient of 0.009204, z-value of 0.11, and p-value of 0.913 indicate a lack of significant impact, which could be attributed to inefficiencies in resource allocation or the influence of confounding factors. The constant term (_cons), with a coefficient of 59.26471, a z-value of 5.78, and a p-value of 0.000, is statistically significant. This represents the estimated mortality rate when all predictors are zero, providing a baseline for understanding the results.

- Urbanisation (URB): exhibits a coefficient of -0.15864, with a standard error of 0.043129, a z-value of -3.68, and a p-value of 0.000. This highly significant result indicates that urbanisation has a strong negative impact on mortality rates, emphasising that increased urbanisation enhances access to healthcare services and leads to better health outcomes.
- Health Infrastructure (HII: shows the most pronounced effect among the confounders, with a coefficient of -0.47815, a standard error of 0.067893, a z-value of -7.04, and a p-value of 0.000. This strong and statistically significant negative relationship underscores the critical role of robust healthcare infrastructure in reducing mortality rates, as access to adequate facilities and trained personnel drastically improves health outcomes.
- In summary, these findings highlight the significant impact of foreign aid on health and population dynamics on mortality rates in Zambia, while government health expenditure appears to lack effectiveness in this context. This underscores the importance of external financial support and population management strategies in improving health outcomes, while pointing to potential areas for strengthening domestic health financing approaches.

3.5. Correlation analysis

Correlation analysis is a statistical method used to examine the strength and direction of the relationship between two or more variables. By measuring the degree to which two variables move about one another, correlation analysis helps identify patterns, trends, and potential dependencies. The most common measure of correlation is the Pearson correlation coefficient, which ranges from -1 to +1, indicating a perfect negative correlation and a perfect positive correlation, respectively. A coefficient close to zero suggests little to no linear relationship between the variables.

Correlation analysis is widely used in various fields, including economics, social sciences, and health research, to understand how variables are interrelated and to inform further analysis or decision-making. However, it is important to note that correlation does not imply causation, meaning that while two variables may move together, one does not necessarily cause the other.

Table 7 Correlation analysis results

Variable	Coef.	P>z
Foreign Aid for Health (FAH)	-0.9588	0
Population Growth (PG)	-0.6774	0
Government Health Expenditure (GHE)	-0.0901	0.5705
Socioeconomic Conditions (SEC)	-0.1482	0
Urbanisation (URB)	-0.2745	0
Health Infrastructure (HII)	-0.5569	0

3.6. Description of Results

The correlation results indicate varying relationships between the independent variables and the dependent variable, Mortality Rate (MR).

Foreign Aid for Health (FAH) exhibits a strong negative effect (coefficient = -0.9588, p = 0.0000), indicating that increased foreign aid significantly reduces mortality rates and enhances health outcomes. Similarly, Population Growth (PG) shows a significant negative coefficient (-0.6774, p = 0.0000), suggesting that higher population growth correlates with lower mortality rates, potentially due to demographic trends such as a younger population.

Government Health Expenditure (GHE) displays a negative coefficient (-0.0901) but lacks statistical significance (p = 0.5705), implying no meaningful impact on mortality rates in this model. Among the confounding variables, Socioeconomic Conditions (SEC) have a statistically significant negative effect (-0.1482, p = 0.0000), highlighting the role of improved income levels, education, and other socioeconomic factors in reducing mortality. Urbanisation (URB) exhibits a coefficient of -0.2745 (p = 0.0000), emphasising the benefits of urban living, such as better access to healthcare services.

Finally, Health Infrastructure (HII) demonstrates the most substantial negative effect (-0.5569, p = 0.0000), underscoring the critical role of healthcare facilities, equipment, and personnel in improving health outcomes and decreasing mortality rates.

Overall, the results highlight the significant impact of external funding, population dynamics, and systemic factors on mortality rates in Zambia, pointing to areas for targeted policy interventions to enhance health outcomes.

3.7. Diagnostic test

The accompanying tests were conducted to check the legitimacy of the consequences of the VAR model results previously introduced by the review.

3.8. Autocorrelation

To test for correlation in the residuals, the study used the Breusch-Godfrey serial correlation LM test, and the results were as follows:

Table 8 Autocorrelation results

Lagrange-multiplier test			
lag	**chi2**	**Df**	**Prob > chi2**
1	0.2224	1	0.63724
2	4.0132	1	0.54515
H0: no autocorrelation at lag order			

The results of the Lagrange-Multiplier (LM) test for autocorrelation at lag orders 1 and 2 suggest that there is no significant autocorrelation in the residuals of the model. For lag 1, the chi-squared statistic is 0.2224 with a p-value of 0.63724, and for lag 2, the chi-squared statistic is 4.0132 with a p-value of 0.54515. Since the p-values for both lags are greater than the conventional significance level of 0.05, we fail to reject the null hypothesis of no autocorrelation at both lag orders. These results indicate that the residuals of the model are independent, supporting the validity of the model's assumption of no autocorrelation.

3.9. Normality test

To test for normality in the residuals, the study used the Jarque-Bera and the results were as follows

Table 9 Normality test results

Equation	chi2	Df	Prob > Chi2
MR	0.158	2	0.92398
ALL	0.158	2	0.92398

The results of the normality test for both the Mortality Rate (MR) and the overall model (ALL) indicate that the variables follow a normal distribution. The chi-squared statistic for both MR and ALL is 0.158, with 2 degrees of freedom, and the p-value is 0.92398 for both cases. Since the p-value is significantly greater than the typical significance threshold of 0.05, we fail to reject the null hypothesis, which suggests that the data do not significantly deviate from a normal distribution. These findings imply that the variables tested exhibit normality, supporting the assumption of normality for further analysis.

3.10. Stability test

This section attempts to investigate whether the period under study had encountered structural changes over the study period and whether it can be used for reliable predictive purposes by monetary authorities. The study employed the eigenvalue stability condition for stability tests on the model. The null hypothesis is that the parameters are stable, while the alternative hypothesis is that the parameters are not stable.

Table 10 Stability test results

Eigenvalue stability condition	
Eigenvalue	**Modulus**
0.8690706 + 0.3760975i	0.94696
0.8690706 - 0.3760975i	0.94696
0.03649034 + 0.8932368i	0.893982
0.03649034 - 0.8932368i	0.893982
-0.8558366 + 0.2254525i	0.885034
-0.8558366 - 0.2254525i	0.885034
-0.5249788 + 0.6508459i	0.836184

-0.5249788 - 0.6508459i	0.836184
0.3257595 + 0.533687i	0.625253
0.3257595 - 0.533687i	0.625253
All the eigenvalues lie inside the unit circle. VAR satisfies the stability condition.	

The eigenvalue stability condition for the Vector Autoregressive (VAR) model has been assessed, with all eigenvalues lying inside the unit circle, indicating that the model satisfies the stability condition. The modulus of each eigenvalue is below 1, with values such as 0.94696, 0.893982, 0.885034, 0.836184, and 0.625253, confirming that the VAR model is stable. Since the modulus of each eigenvalue is less than 1, this suggests that the system is stable and the model's dynamics will not lead to explosive behaviour. Therefore, the stability of the VAR model is ensured, making it suitable for further analysis and forecasting.

4. Discussion

4.1. The Extent to Which Foreign Aid Contributes to Reducing Mortality Rates in Zambia

Foreign Aid for Health (FAH) demonstrated a significant negative relationship with mortality rates in Zambia, with a coefficient of -0.28781 ($p = 0.000$). This underscores the critical role of external funding in addressing healthcare challenges, particularly in resource-constrained settings. FAH has been instrumental in improving access to essential medications, enhancing healthcare infrastructure, and training healthcare workers, as evidenced by programs like PEPFAR and the Global Fund (WHO, 2022). These initiatives have significantly contributed to reducing mortality rates by targeting high-priority areas such as infectious disease control and maternal and child health.

Comparatively, similar findings have been observed in Malawi, where foreign aid has played a pivotal role in reducing maternal and child mortality rates by funding immunisation programs and rural healthcare services. However, dependency on donor funding remains a shared challenge for both Zambia and Malawi, as aid volatility and shifting donor priorities can disrupt healthcare services [11]. A study on sub-Saharan Africa further highlights that while foreign aid improves health outcomes, its effectiveness is amplified when combined with robust domestic health systems and socioeconomic improvements.

Confounding factors such as Socioeconomic Conditions (SEC), Urbanisation (URB), and Health Infrastructure (HII) also influence the effectiveness of FAH. Higher SEC levels, better urbanisation, and strong health infrastructure create an enabling environment for foreign aid to achieve greater impact. For instance, urbanisation facilitates access to donor-funded healthcare services, while improved infrastructure ensures the efficient delivery of aid-supported programs.

4.2. Government Health Expenditure Impacts Health Outcomes and Effects on Systemic Challenges in Healthcare Delivery

Government Health Expenditure (GHE) showed no statistically significant effect on mortality rates in Zambia, with a coefficient of -0.0901 ($p = 0.5705$). This finding suggests that increased government spending does not automatically translate into improved health outcomes, likely due to inefficiencies in resource allocation and systemic challenges. Similar trends have been observed in other low-income countries, where higher health spending often fails to reduce mortality rates due to corruption, poor governance, and inadequate workforce capacity [12, 13].

Comparative studies in sub-Saharan Africa reveal that the impact of GHE on health outcomes is stronger in countries with better governance and accountability mechanisms. For example, Rwanda has successfully leveraged government health expenditure to improve maternal and child health outcomes by prioritising primary healthcare and ensuring efficient resource allocation4. In contrast, Zambia's health sector faces challenges such as mismanagement of funds and insufficient investment in critical areas like primary healthcare and disease prevention.

Confounding variables such as SEC, URB, and HII further contextualise these findings. Improved socioeconomic conditions and urbanisation enhance the effectiveness of government spending by increasing access to healthcare services. Additionally, robust health infrastructure, as reflected in the significant negative coefficient of HII, is essential for translating government expenditure into tangible health improvements.

4.3. Moderating Effect of Population Growth on the Relationship Between Health Financing and Mortality Rates in Zambia

Population Growth (PG) exhibited a significant negative effect on mortality rates, with a coefficient of -6.47965 (p = 0.000). This inverse relationship can be attributed to Zambia's youthful demographic profile, where a larger proportion of the population is in low-risk age groups. Similar trends have been observed in other African nations with rapidly growing populations, such as Uganda and Kenya, where a youthful population structure temporarily reduces mortality rates [14].

However, the long-term implications of population growth pose challenges for Zambia's healthcare system. A growing population increases demand for healthcare services and infrastructure, which may strain existing resources if investments do not keep pace. Comparative studies highlight that countries such as Ethiopia have successfully managed the pressures of population growth by investing in healthcare infrastructure and workforce development. In Zambia, confounding factors such as URB and HII play critical roles in moderating the effects of population growth. Urbanisation facilitates access to healthcare services in high-growth areas, while robust health infrastructure offsets the pressures of a rapidly growing population.

Strategic investments in education, healthcare, and job creation are essential to leverage Zambia's demographic dividend while preparing for future challenges. As the population ages, the burden of non-communicable diseases is expected to rise, necessitating a well-resourced and efficient healthcare system to mitigate potential increases in mortality rates [2]. Zambia's demographic structure offers a temporary advantage due to the low-risk age distribution. However, the healthcare system must prepare for the anticipated demands of an ageing population in the coming decades. Lastly, the ineffectiveness of government health expenditure in reducing mortality underscores the need for systemic reform, focusing on improving governance and resource allocation to ensure that health spending yields tangible benefits

5. Conclusion

This study demonstrates that foreign aid for health plays a vital role in reducing mortality in Zambia by expanding access to essential medicines and supporting targeted programs. However, reliance on external funding introduces risks related to donor priority shifts, underscoring the need for a strategy that blends aid with stronger domestic financing. In contrast, government health expenditure alone did not significantly lower mortality, highlighting inefficiencies in resource allocation and governance. Enhancing accountability, improving infrastructure, and building workforce capacity are necessary to ensure that increased public spending translates into better health outcomes.

Population growth currently contributes to lower mortality through Zambia's youthful demographic, but it also presents long-term pressures on healthcare infrastructure and service delivery. To harness this demographic advantage, coordinated investments in education, infrastructure, and employment are essential. Overall, these findings emphasise the importance of balanced, sustainable health financing, integrating foreign aid with effective government spending and proactive planning for demographic change to achieve lasting improvements in Zambia's health sector.

This study therefore recommends the following:

- The government, in collaboration with private sector partners and civil society organisations, should strengthen public-private partnerships (PPPs) to support sustainable healthcare financing, including joint investments in rural health infrastructure and regular stakeholder engagement aligned with national health priorities.
- The Ministry of Health should establish a robust donor coordination framework to align foreign aid with Zambia's health needs, ensuring that development partners contribute to national goals through active participation in health sector working groups.
- Government agencies should engage international donors, private entities, and local communities in planning and implementing healthcare infrastructure projects, with a focus on underserved rural areas lacking adequate health services.
- The government should implement reforms to enhance efficiency in the healthcare system by addressing corruption, mismanagement, and poor resource allocation. This should include regular audits, transparent reporting of health expenditures, and stakeholder oversight mechanisms.
- Training institutions and professional associations should collaborate to develop healthcare workforce capacity through continuous education programs. NGOs should support this effort by advocating for good governance and transparency in health sector spending.

- Health policymakers, academic researchers, and community organisations should work together to prepare for future demographic shifts by investing in elderly care services and preventive programs targeting noncommunicable diseases (NCDs), including public awareness campaigns on lifestyle-related health risks

Compliance with ethical standards

Disclosure of conflict of interest

The author declares no conflict of interest.

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