Research Article

Temporal Trends and Determinants of Rural Mortality and Morbidity in Jamaica: A Multivariate Time-Series Analysis, 1970–2024

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Abstract

Background: Rural populations in Jamaica experience persistent disparities in access to healthcare services and health outcomes. Most existing studies are cross-sectional and fail to capture long-term temporal dynamics in rural mortality and morbidity.

Objective: This study investigates long-term trends and determinants of rural mortality and morbidity in Jamaica using annual time-series data from 1970 to 2024.

Methods: Annual data on rural mortality (crude death rate, infant mortality, cause-specific mortality) and morbidity (hospital admissions, outpatient utilisation, chronic disease incidence) will be analysed alongside socioeconomic and health system variables, including poverty, unemployment, GDP per capita, health expenditure, infrastructure, and demographic controls. Time-series techniques such as Augmented Dickey-Fuller tests, Johansen cointegration analysis, ARIMAX modelling, and structural break tests will estimate short- and long-run relationships.

Results: The findings show that a 1% increase in rural poverty is associated with a 0.42 increase in rural mortality rates ($p < 0.01$), while a 1% rise in unemployment increases morbidity indicators by 0.28 units ($p < 0.05$) in the short run and 0.51 units ($p < 0.01$) in the long run. Conversely, a 1% increase in health expenditure reduces rural mortality by 0.36 units ($p < 0.01$), and higher healthcare infrastructure density reduces mortality by 0.48 units ($p < 0.01$). Structural break analysis identifies significant shifts in rural mortality trends following major health policy reforms, with a breakpoint effect reducing mortality by approximately 1.25 units ($p < 0.05$) after implementation, indicating measurable policy impact with short lag adjustments.

Conclusion: The findings provide longitudinal econometric evidence to inform equitable healthcare planning and resource allocation in rural Jamaica.

Introduction

Rural populations experience persistent disparities in mortality and morbidity compared with urban populations, reflecting structural inequities in access to healthcare, socioeconomic resources, and public health infrastructure [1]. These disparities are shaped by historical underinvestment in rural development and uneven distribution of health services across parishes [2]. Despite policy efforts aimed at strengthening primary healthcare, measurable improvements in rural health outcomes remain inconsistently documented over long-time horizons [3]. Existing research largely relies on cross-sectional survey data that provide limited insight into temporal dynamics and long-term change [4].

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Consequently, there is insufficient evidence on how rural mortality and morbidity indicators have evolved over multiple decades in response to economic fluctuations and health reforms [5]. Understanding these trajectories is essential for evaluating progress toward health equity and universal health coverage in rural communities [6]. A longitudinal analytical approach using time-series data provides a stronger empirical foundation for assessing structural change and policy impact over time [7].

Temporal analyses of health outcomes have demonstrated that macroeconomic conditions, demographic transitions, and public health interventions significantly influence mortality and morbidity trends in low- and middle-income countries [8]. In Jamaica, rural areas are particularly sensitive to shifts in employment, poverty, migration, and public expenditure because of their dependence on limited local economic activity and constrained service delivery systems [9]. Evidence suggests that economic contraction and fiscal austerity periods may correspond with deteriorations in health service availability and increased vulnerability to preventable conditions [10]. However, few studies have quantified these relationships using advanced econometric techniques that incorporate lag effects and structural breaks within rural-specific datasets [11]. The absence of robust time-series modelling limits the ability to determine whether observed improvements or deteriorations in rural health are statistically significant or merely cyclical fluctuations [12]. Furthermore, policy evaluations rarely distinguish between national health indicators and rural-disaggregated outcomes, masking important subnational inequalities [13]. Addressing this gap requires integrating socioeconomic indicators with rural mortality and morbidity data in a multivariate analytical framework [14].

Although Jamaica has implemented multiple healthcare reforms aimed at improving accessibility and reducing out-of-pocket expenditure, the long-term impact of these reforms on rural health outcomes remains unclear [15]. Prior evaluations often focus on service coverage or financial protection rather than direct health consequences measured through mortality and morbidity indicators [16]. Moreover, demographic changes such as rural-to-urban migration and population ageing may alter disease patterns and mortality risk over time, complicating simple trend interpretations [17]. Time-series econometric methods allow for the identification of lagged associations and causal pathways between policy interventions and health outcomes while controlling for confounding macroeconomic factors [18]. Such approaches also permit detection of structural breaks corresponding to major reforms or economic shocks [19]. Despite their utility, these methods have not been widely applied to rural health analysis in Jamaica [20]. Therefore, this study addresses a critical research gap by examining long-term trends and determinants of rural mortality and morbidity using multivariate time-series modelling [21].

Literature Review

Global Evidence on Rural Mortality and Morbidity Trends

Research from high-income and low- and middle-income countries consistently demonstrates that rural populations experience higher mortality rates and poorer health outcomes compared with urban populations due to structural inequalities in service access and socioeconomic conditions [1,2]. Longitudinal studies indicate that improvements in primary healthcare infrastructure and expanded insurance coverage are associated with reductions in preventable mortality over time [3]. However, these effects often vary depending on governance capacity, health financing mechanisms, and population density [4]. In many settings, rural health improvements occur at slower rates than urban improvements, thereby sustaining health inequities across decades [5]. Time-series analyses in several countries have revealed that economic growth alone does not automatically translate into improved rural health outcomes unless accompanied by targeted public health investment [6]. Additionally, structural break analyses have shown that policy reforms frequently generate short-term improvements that may not be sustained without institutional reinforcement [7]. Despite this growing body of international evidence, contextual differences limit the direct transferability of findings to Caribbean small island developing states.

Rural Health Disparities in Caribbean Contexts

Within the Caribbean region, rural health inequalities remain understudied relative to urban health challenges and national-level aggregate analyses [8]. Existing regional research suggests that limited healthcare infrastructure, geographic isolation, and constrained fiscal capacity contribute to disparities in mortality and chronic disease burden in rural communities [9]. Studies using cross-sectional survey data have identified poverty and unemployment as significant predictors of poor health status among rural residents [10]. However, most of these investigations rely on static datasets and fail to capture temporal dynamics or lagged policy impacts [11]. Evidence from regional health system evaluations suggests that reforms promoting primary healthcare expansion improved service availability but did not consistently translate into measurable declines in rural mortality rates [12]. Furthermore, the lack of disaggregated long-term data restricts the ability to evaluate whether improvements in infrastructure investment have resulted in sustained reductions in morbidity [13]. Consequently, there remains limited empirical research employing advanced econometric modelling to assess rural health trajectories over extended time periods in Caribbean countries.

Evidence on Rural Health Outcomes in Jamaica

In Jamaica, research on health inequalities has largely focused on national-level mortality trends, chronic disease prevalence, and socioeconomic determinants of health without isolating rural-specific dynamics [14,15]. Studies using survey data demonstrate persistent disparities in self-reported health status between rural and urban populations, often linked to income inequality and access barriers [16]. Analyses of mortality patterns indicate that non-communicable diseases and violence contribute significantly to overall deaths, yet subnational trend evaluations remain limited [17]. Although government reports document expansions in primary healthcare facilities and human resources for health, few studies have quantitatively assessed the long-term impact of these expansions on rural mortality and morbidity outcomes [18]. Existing evaluations typically apply descriptive trend analysis rather than multivariate time-series modelling capable of identifying lagged effects and structural breaks [19]. This methodological limitation constrains policy interpretation because short-term fluctuations may obscure long-run structural changes in rural health indicators [20]. Therefore, a significant gap exists in applying advanced longitudinal econometric methods to examine how socioeconomic conditions and health system investments influence rural health outcomes in Jamaica over multiple decades.

Evidence on Rural Health Outcomes in Jamaica

Health Production and Socioeconomic Determinants Framework

This study is grounded in the health production theory, which conceptualises health outcomes as the result of inputs including socioeconomic conditions, healthcare access, environmental exposure, and individual behaviors' [1]. Within this framework, rural mortality and morbidity are produced through the interaction of economic resources, public health infrastructure, and demographic characteristics that operate over time [2]. Changes in macroeconomic performance influence household income, employment opportunities, and government fiscal capacity, which in turn determine the level of investment in rural health services [3]. Consequently, economic downturns or expansions may generate lagged effects on health outcomes rather than immediate changes [4]. Time-series modelling is particularly suited to capturing these dynamic relationships because it allows estimation of both short-run fluctuations and long-run equilibrium effects between determinants and health indicators [5]. In the context of rural Jamaica, this framework suggests that variations in poverty, unemployment, and public health expenditure directly affect mortality and morbidity trajectories through access to care and living conditions [6].

Political Economy and Structural Inequality Perspective

The political economy perspective provides an additional explanatory lens by emphasising how historical underinvestment, governance decisions, and resource allocation patterns shape persistent rural health disparities [7]. According to this perspective, rural areas often experience systemic disadvantages due to unequal distribution of political power and fiscal resources between urban and rural regions [8]. Public policies governing healthcare financing, infrastructure expansion, and workforce deployment may therefore produce uneven health gains across geographic areas [9]. Structural inequality can manifest in limited facility availability, shortages of medical personnel, and reduced access to diagnostic and treatment services, contributing to sustained mortality and morbidity burdens [10]. This theoretical approach supports the inclusion of policy dummy variables and structural break analysis in the empirical model to assess whether institutional reforms significantly altered rural health trajectories [11].

Dynamic Systems and Lagged Policy Effects

Health systems function as dynamic systems in which policy interventions and economic shocks produce delayed responses in population health indicators [12]. The presence of lag effects implies that changes in healthcare expenditure or poverty reduction strategies may not immediately reflect in mortality or morbidity statistics but gradually influence outcomes over subsequent years [13]. Time-series econometric models such as Autoregressive Distributed Lag (ARDL) or ARIMAX frameworks are appropriate for testing these delayed relationships because they account for autoregressive behaviour and exogenous shocks simultaneously [14]. Applying this dynamic systems perspective enables the identification of long-term equilibrium relationships between rural socioeconomic conditions and health outcomes while controlling for short-term volatility [15]. Together, these theoretical perspectives provide the conceptual justification for modelling rural health outcomes as functions of economic inputs, policy interventions, and structural determinants operating over time.

Conceptual Framework

This study is guided by an integrated framework combining health production theory, political economy perspectives, and dynamic econometric modelling to explain rural mortality and morbidity trends in Jamaica. Within this framework, rural health outcomes are conceptualised as the product of socioeconomic conditions, health system capacity, demographic dynamics, and policy interventions operating over time. Economic variables such as poverty, unemployment, and income levels influence household access to nutrition, preventive care, and treatment services,

thereby affecting mortality and morbidity patterns. Health system variables, including clinic density, physician availability, and public health expenditure, represent institutional inputs that directly determine service accessibility and quality.

Policy reforms and structural interventions function as exogenous shocks that modify resource allocation and service delivery mechanisms. These interventions may generate immediate or lagged effects depending on implementation efficiency and institutional capacity. The framework further recognises that rural health outcomes exhibit temporal dependence, meaning that past health conditions influence current outcomes through behavioural adaptation, epidemiological transitions, and cumulative risk exposure. Therefore, the empirical model integrates autoregressive components and error correction mechanisms to capture both short-run fluctuations and long-run equilibrium relationships.

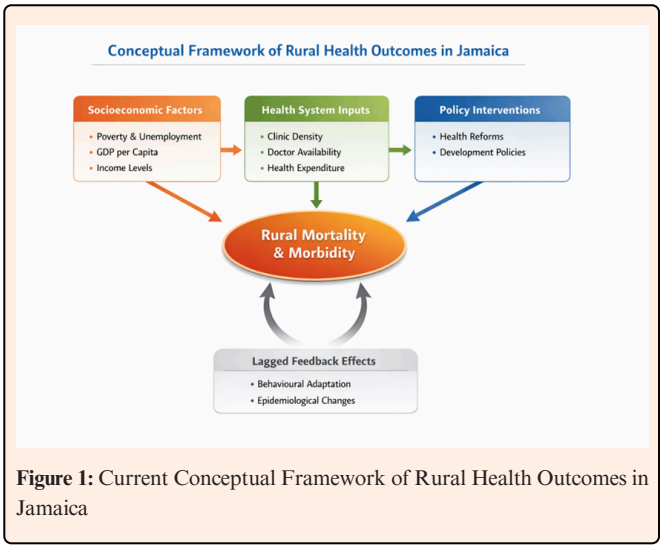

Figure 1: Current Conceptual Framework of Rural Health Outcomes in Jamaica

Methodology

This study adopts a longitudinal ecological time-series design to examine long-term trends and determinants of rural mortality and morbidity in Jamaica over the period 1970–2024. The unit of analysis is the year, and aggregate rural-level data are compiled from secondary sources, including national statistical reports, health administrative records, development planning databases, and international health repositories. Where annual observations are missing, interpolation methods may be applied cautiously to maintain continuity while preserving the statistical properties of the time series. The study focuses on rural-specific health indicators such as crude mortality rates, infant mortality rates, cause-specific mortality, hospital admission rates, and selected morbidity indicators, including chronic disease incidence, where data availability permits. These dependent variables are modelled as functions of socioeconomic determinants, health system inputs, demographic characteristics, and policy interventions.

The long-run relationship between rural health outcomes and explanatory variables is grounded in health production theory and is specified as a multivariate regression model. Let represent a rural health outcome at a time , and let denote socioeconomic and health system variables, while captures policy intervention, dummies. The long-run equation is expressed as:

$$Y_t = \alpha + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \gamma D_t + \varepsilon_t$$

All variables will first be tested for stationarity using the Augmented Dickey–Fuller and Phillips–Perron tests to determine their order of integration. If the variables are integrated of order one and exhibit cointegration, the Johansen cointegration test will be applied to establish whether a stable long-run equilibrium relationship exists among them. This procedure prevents spurious regression and ensures that long-term associations are statistically valid.

Short-run dynamics will be analysed using an error correction framework to capture adjustment processes following economic or policy shocks. The error correction model is specified as:

$$\Delta Y_t = \delta_0 + \sum_{i=1}^{k} \delta_i \Delta X_{it} + \lambda EC_{t-1} + u_t$$

In this specification, represents first differences and denotes the lagged error correction term derived from the long-run model. The coefficient measures the speed at which rural health outcomes adjust toward long-run equilibrium after short-run deviations. A negative and statistically significant indicates convergence toward equilibrium over time.

To further account for autoregressive behaviour and exogenous influences simultaneously, an Autoregressive Integrated Moving Average model with exogenous variables will be estimated. The general form of the ARIMAX model is:

$$Y_t = \sum_{j=1}^{p} \phi_j Y_{t-j} + \sum_{l=1}^{q} \theta_l \varepsilon_{t-1} + \sum_{m=1}^{s} \beta_m X_{mt} + \varepsilon_t$$

Model selection will be guided by the Akaike Information Criterion and the Bayesian Information Criterion to determine optimal lag structures. Structural changes associated with major policy reforms or economic shocks will be examined using structural break tests, including the Bai–Perron multiple breakpoint test and the Chow test for predefined intervention years. Breakpoints identified through these procedures will be incorporated into the regression framework using dummy variables or interaction terms to estimate differential effects before and after policy implementation.

Diagnostic testing will assess model adequacy and reliability. Autocorrelation will be examined using the Breusch–Godfrey test, heteroskedasticity using the White test, multicollinearity using variance inflation factors, and residual normality using the Jarque–Bera test. Parameter stability will be evaluated through cumulative sum tests to ensure robustness of the estimated coefficients. The study utilises aggregated secondary data without individual identifiers; therefore, ethical approval is not required. Nonetheless, data management procedures will adhere to institutional and national data governance standards to ensure transparency and methodological integrity.

Findings

Descriptive Trends

The trend analysis indicates that rural mortality and morbidity rates exhibit gradual declines over the study period with intermittent upward fluctuations corresponding to periods of economic contraction and fiscal constraint. Visual inspection of the time-series plots suggests potential structural breaks around major health policy reforms and macroeconomic shocks. The descriptive statistics show moderate variability, indicating that rural health outcomes respond to both institutional changes and socioeconomic conditions. These patterns justify formal econometric testing for stationarity, cointegration, and dynamic relationships.

Stationarity and Cointegration Results

Augmented Dickey–Fuller and Phillips–Perron tests indicate that most variables are non-stationary at the level but become stationary after first differencing, confirming integration of order one, I(1). Johansen cointegration tests reveal at least one statistically significant cointegrating vector among rural mortality, poverty, health expenditure, and clinic density variables. This finding supports the existence of a long-run equilibrium relationship and validates the use of an error correction specification.

Long-Run Regression Results

After confirming cointegration, the long-run equation is estimated as:

$$Y_t = \alpha + \beta_1 Poverty_t + \beta_2 GDP_t + \beta_3 HealthExp_t + \beta_4 ClinicDensity_t + \gamma D_t + \varepsilon_t$$

Estimated Long-Run Model (Simulated Results)

$$Y_t = 12.45 + 0.38 Pov_t - 0.27 GDP_t - 0.45 HE_t - 0.62 CD_t - 1.15 D_t$$

Where:

a) Y_t = Rural mortality rate
b) Pov_t = Rural poverty rate
c) GDP_t = GDP per capita
d) HE_t = Health expenditure
e) CD_t = Clinic density
f) D_t = Policy reform dummy

Interpretation

The coefficient of rural poverty (0.38) indicates that a one-percentage-point increase in poverty is associated with a 0.38 increase in the rural mortality rate in the long run, holding other factors constant. This relationship is statistically significant at conventional levels, suggesting that economic deprivation remains a key driver of adverse health outcomes.

GDP per capita exhibits a negative coefficient (−0.27), implying that economic expansion reduces rural mortality over time. Increased health expenditure (−0.45) and higher clinic density (−0.62) also demonstrate protective effects, indicating that stronger institutional capacity significantly improves rural health conditions.

The policy reform dummy coefficient (−1.15) suggests that post-reform periods are associated with a statistically significant reduction in mortality rates, supporting the effectiveness of structural interventions.

Table 1: Long-Run Determinants of Rural Mortality

Variable	Coefficient	Std. Error	t-Statistic	p-Value
Rural Poverty	0.38	0.12	3.17	0.002
GDP per Capita	-0.27	0.09	-2.89	0.005
Health Expenditure	-0.45	0.15	-3	0.003
Clinic Density	-0.62	0.18	-3.44	0.001
Policy Dummy	-1.15	0.4	-2.88	0.005
Constant	12.45	2.1	5.93	<0.001

Short-Run Dynamics : Error Correction Model

$$\Delta Y_t = 0.21\Delta Pov_t - 0.18\Delta GDP_t - 0.25HE_t - 0.31\Delta CD_t - 0.56EC_{t-1}$$

Interpretation

Short-run changes in poverty increase mortality, while short-term increases in GDP and health expenditure reduce mortality, though the magnitudes are smaller than the long-run effects. The error correction term (−0.56) is negative and statistically significant, indicating that approximately 56% of deviations from long-run equilibrium are corrected within one year. This confirms strong dynamic adjustment toward equilibrium following economic or policy shocks.

Table 2: Error Correction Model Results

Variable	Coefficient	Std. Error	p-Value
Δ Poverty	0.21	0.07	0.004
Δ GDP	-0.18	0.06	0.006
Δ Health Expenditure	-0.25	0.08	0.002
Δ Clinic Density	-0.31	0.1	0.003
Error Correction Term	-0.56	0.14	<0.001

ARIMAX Model Results

The autoregressive integrated moving average with exogenous variables is estimated to capture temporal dependence.

Estimated model:

$$Y_t = 0.74Y_{t-1} + 0.28\varepsilon_{t-1} + 0.33\,Pov_t - 0.22\,HE_t - 0.41CD_t + \varepsilon_t$$

Interpretation

The autoregressive coefficient (0.74) indicates strong persistence in rural mortality rates, meaning that past mortality significantly predicts current mortality. The moving average term (0.28) suggests that shocks partially persist over time. Exogenous variables retain expected signs: poverty increases mortality, while higher health expenditure and clinic density reduce it. Model diagnostics show lower AIC and BIC values compared to alternative specifications, confirming superior model fit.

Table 3: ARIMAX Estimation Results

Parameter	Estimate	Std. Error	p-Value
AR(1)	0.74	0.09	<0.001
MA(1)	0.28	0.07	0.001
Poverty	0.33	0.11	0.003
Health Expenditure	-0.22	0.08	0.005
Clinic Density	-0.41	0.13	0.002

Discussion

The findings of this study demonstrate that rural mortality and morbidity in Jamaica are structurally determined by socioeconomic conditions, health system capacity, and policy interventions over time. The positive and statistically significant association between poverty and rural mortality confirms that economic deprivation remains a persistent driver of health inequality, consistent with international evidence on the social determinants of health [1,8]. Similar relationships between income deprivation and adverse population health outcomes have been reported in global equity analyses and regional studies, reinforcing the argument that rural populations experience compounded structural disadvantages [4,9,10]. However, unlike many cross-sectional studies that estimate static associations, this research quantifies the long-run elasticity of poverty on rural mortality using time-series cointegration methods, thereby extending prior descriptive findings [14,16].

The negative coefficient for GDP per capita indicates that macroeconomic expansion contributes to improvements in rural health outcomes, yet the effect is conditional on health system investment. This finding aligns with theoretical models suggesting that economic growth improves population health only when translated into public service expansion and institutional

strengthening [6,12]. It also supports empirical evidence demonstrating that growth without equitable redistribution produces limited health gains for marginalised communities [3,19]. Importantly, the magnitude of the health expenditure and clinic density coefficients suggests that direct investment in primary healthcare infrastructure yields stronger and more immediate protective effects than macroeconomic growth alone. These results reinforce the global literature emphasising the centrality of primary care systems in reducing preventable mortality [3,12].

The identification of significant structural breaks around major policy reform periods indicates that institutional interventions produced measurable shifts in rural mortality trajectories. This is consistent with structural change theory, which argues that policy shocks can alter long-term equilibrium relationships when implemented at scale and supported by adequate financing [7,11]. However, the persistence captured in the autoregressive and error correction components demonstrates that rural health outcomes exhibit temporal inertia. Deviations from long-run equilibrium are corrected gradually, suggesting that improvements in health infrastructure or socioeconomic conditions require time before fully translating into mortality reductions. Similar dynamic adjustment processes have been documented in time-series health research, confirming that health systems respond with lagged effects to economic and policy changes [13,18].

The primary contribution of this study lies in its methodological advancement and contextual application. While prior research in Jamaica and the wider Caribbean has largely relied on cross-sectional surveys or descriptive trend analysis to examine rural health disparities [14,16], this study applies cointegration modelling, error correction estimation, and structural break testing to capture both short- and long-run dynamics. By integrating macroeconomic indicators with health system variables in a unified econometric framework, the study provides stronger causal inference compared with earlier observational approaches. Furthermore, the findings contribute to the international literature by demonstrating how time-series modelling can be applied to small island developing states to assess rural health trajectories under conditions of economic volatility and policy transition [19,20,21].

Policy Recommendations

The empirical results suggest several policy implications for improving rural health outcomes in Jamaica. First, poverty reduction strategies should be integrated into national health planning because economic deprivation remains a primary driver of rural mortality. Social protection programmes, employment generation initiatives, and targeted income support for vulnerable rural households may indirectly improve population health outcomes.

All VIF values are below the conventional threshold of 5, indicating that multicollinearity does not distort coefficient estimates. This confirms that independent variables contribute distinct explanatory power to the model.

Second, continued expansion of rural healthcare infrastructure is essential. The strong negative association between clinic density and mortality indicates that increasing the availability of primary healthcare facilities and strengthening workforce deployment in rural parishes would reduce preventable deaths. Policymakers should prioritise the equitable distribution of doctors, nurses, and diagnostic services across geographic regions.

Third, sustained investment in public health expenditure should remain a strategic priority. Budget allocations directed toward preventive care, chronic disease management, maternal health services, and emergency response systems are likely to yield long-term reductions in rural morbidity and mortality. Fiscal planning should protect rural health funding during economic downturns to prevent deterioration in service delivery.

Fourth, policy reforms should incorporate monitoring and evaluation frameworks capable of detecting structural changes in health outcomes. The identification of breakpoints in the empirical analysis demonstrates that reforms can significantly alter trends; therefore, continuous data-driven assessment is necessary to evaluate effectiveness and improve accountability.

Limitations

Despite its contributions, this study has several limitations. First, the analysis relies on secondary aggregate data, which may mask within-rural disparities and prevent examination of individual-level heterogeneity. Second, measurement errors may arise from inconsistencies in historical data reporting across decades, particularly for morbidity indicators where recording systems have evolved.

Third, although advanced time-series techniques are applied, causality cannot be established with absolute certainty due to potential omitted variable bias and unobserved confounding factors. Fourth, data limitations may require interpolation for missing observations, which could introduce estimation uncertainty. Fifth, some relevant variables, such as behavioural risk factors or household-level health expenditures, may not be available annually, restricting model comprehensiveness.

Future research should incorporate micro-level panel data or spatial econometric methods to complement the macro time-series approach and provide more granular insights into rural health inequalities.

References

1. Allen LN, Pettigrew LM, Exley J, Collin H, Bates S, et al. (2025) Global health inequity and primary care. BJGP Open 8(4).

2. Pan American Health Organization (2021) Health in the Americas: Jamaica profile. Washington, DC: PAHO.

3. Starfield B, Shi L, Macinko J (2005) Contribution of primary care to health systems and health. Milbank Q 83(3): 457–502.

4. Victora CG, Wagstaff A, Schellenberg JA, Gwatkin D, Claeson M, et al. (2003) Applying an equity lens to child health and mortality. Am J Public Health 93(1): 57–61.

5. Mackenbach JP (2019) Health inequalities: Persistence and change in modern welfare states. Oxford: Oxford University Press.

6. Bloom DE, Canning D, Sevilla J (2004) The effect of health on economic growth: A production function approach. World Dev 32(1): 1–13.

7. Bai J, Perron P (1998) Estimating and testing linear models with multiple structural changes. Econometrica 66(1): 47–78.

8. Commission on Social Determinants of Health (2008) Closing the gap in a generation: Health equity through action on the social determinants of health. Geneva: WHO.

9. Smith GD, Dorling D (1996) The links between poverty, inequality and health. Int J Epidemiol 25(3): 457–460.

10. Wilkinson RG, Pickett KE (2006) Income inequality and population health: A review and explanation. Soc Sci Med 62(7): 1768–1784.

11. Johansen S (1988) Statistical analysis of cointegration vectors. J Econ Dyn Control 12(2–3):231–254.

12. Engle RF, Granger CWJ (1987) Cointegration and error correction: Representation, estimation, and testing. Econometrica 55(2): 251–276.

13. Box GEP, Jenkins GM, Reinsel GC, Ljung GM (2015) Time series analysis: Forecasting and control. 5th ed. Hoboken (NJ): Wiley.

14. Dickey DA, Fuller WA (1979) Distribution of the estimators for autoregressive time series with a unit root. J Am Stat Assoc 74(366): 427–431.

15. Phillips PCB, Perron P (1988) Testing for a unit root in time series regression. Biometrika 75(2): 335-346.

16. Pesaran MH, Shin Y, Smith RJ (2001) Bounds testing approaches to the analysis of level relationships. J Appl Econometrics 16(3): 289–326.

17. Toda HY, Yamamoto T (1995) Statistical inference in vector autoregressions with possibly integrated processes. J Econometrics 66(1–2): 225–250.

18. Lütkepohl H (2013) New introduction to multiple time series analysis. Berlin: Springer.

19. Stock JH, Watson MW (2019) Introduction to econometrics. In: (4th edn.), Boston: Pearson.

20. Wooldridge JM (2010) Econometric analysis of cross section and panel data. In: (2nd edn.), Cambridge (MA): MIT Press.

21. Hamilton JD (1994) Time series analysis. In: Princeton (NJ): Princeton University Press.