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Examining the Dynamics of Infant Mortality Rates: A Time Series Analysis

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Abstract

This paper examines the relationship between infant mortality rates and various independent variables. The Augmented Dickey-Fuller test and unit root tests are employed to assess the stationarity of time series data, ensuring reliable statistical analysis. Stationarity is crucial in time series analysis, as it implies that the statistical properties of a series remain constant over time. The ADF test determines whether a time series exhibits a unit root, indicating non-stationarity. If the test statistic falls below the critical value at a given significance level, the null hypothesis of a unit root is rejected, confirming stationarity. This study utilizes the Autoregressive Distributed Lag (ARDL) model to investigate the relationship between infant mortality rates and key independent variables from 1975 to 2014. Findings reveal significant negative associations between infant mortality and several factors. Increased health expenditure is strongly correlated with lower infant mortality rates, emphasizing the importance of healthcare investment. Additionally, higher female education enrollment contributes to reduced infant mortality, underscoring education's role in improving maternal and child health. Lower unemployment rates also correspond to decreased infant mortality, highlighting the impact of economic stability. Unexpectedly, inflation exhibits a negative relationship with infant mortality, requiring further investigation. The presence of lady health visitors and rural health centers significantly reduces infant mortality, reinforcing the importance of accessible healthcare services. These results emphasize the multifaceted nature of infant mortality determinants and the need for integrated healthcare, education, and socioeconomic policies to enhance infant health outcomes over time.

Keywords: Infant Mortality Rates, Stationarity, Autoregressive Distributed Lag Modeling

1. INTRODUCTION

The current paper represents a pioneering effort to examine the comparative impact of private and public health expenditure on infant mortality rates in Pakistan, as well as to elucidate other determinants influencing infant mortality rates. Alongside private and public health expenditure, the regression equations incorporate a range of other explanatory variables, allowing for a comprehensive examination of the factors influencing infant mortality in Pakistan over the specified time period. Recent literature also emphasizes how demographic conditions, institutional quality, and policy structure shape human development (Khan, 2019; Kumar, 2018). Building on the literature review presented above, our study focuses on several key variables, including unemployment, lady health visitors, rural health centers, and inflation. This line of inquiry further supports the understanding that human capital development and technological accessibility contribute to long-term well-being (Ali & Afzal, 2019; Bibi, 2019). Notably, our approach differs from previous research in this field in several respects. Firstly, to our knowledge, ours is the first study to disaggregate health expenditure into its private and public components, aiming to assess their respective impacts on infant mortality rates. In doing so, the study addresses strategic health planning and institutional investment as mechanisms for sustainability (Farahmand, 2019; Ahmad, 2018). This novel approach allows for a more nuanced understanding of the relationship between health spending and infant mortality rates, shedding light on the distinct effects of private and public investment in healthcare on infant health outcomes (Ali and Ahmad, 2014; Ali, 2015). Our study stands out as the first to utilize time series data techniques in examining the relative impacts of private and public health expenditures on infant mortality rates. This methodological approach allows for a comprehensive analysis of the trends and dynamics underlying infant mortality rates over time, offering valuable insights into the effectiveness of different health spending strategies. The findings from our research hold significant policy implications, highlighting the need for governments and international organizations to carefully

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consider the balance between private and public health investment in their efforts to enhance child health outcomes and reduce infant mortality rates. By understanding the nuanced relationship between health expenditure mechanisms and infant mortality, policymakers can better tailor their interventions to address the specific needs and challenges faced by vulnerable populations, ultimately leading to improved health outcomes for infants and children worldwide.

The findings of Gupta et al. (2001) underscore the importance of public spending on health, particularly for the welfare of the poor in low-income countries. Their study, based on evidence from 70 countries, suggests that public health expenditure plays a crucial role in improving health outcomes, with higher returns observed in low-income countries compared to high-income ones. Similarly, Annand and Ravallion (1993) conducted a cross-country study across 22 developing nations, revealing that public health expenditure significantly contributes to improvements in life expectancy at birth. These findings highlight the pivotal role of government investment in healthcare infrastructure and services in fostering better health outcomes for populations, especially in resource-constrained settings (Khan, 2019; Ahmad, 2018). Furthermore, Hanmer et al. (2003) examined the determinants of infant and child mortality in developing countries, finding that alongside per capita income levels, health and education variables emerge as robust determinants. This is also supported by studies exploring governance and remittance-driven human development (Kumar, 2018; Ali & Afzal, 2019). This underscores the multifaceted nature of factors influencing mortality rates, emphasizing the need for comprehensive approaches addressing healthcare access, education, and economic development to improve health outcomes in developing nations. Turner's (1991) study focusing on Nicaragua highlights the critical role of access to healthcare facilities in determining infant mortality rates. By examining the situation in Nicaragua, Turner underscores that improved accessibility to healthcare services emerges as the most significant factor influencing infant mortality outcomes. In parallel, infrastructural accessibility and regional equity in public health investment have shown promising results across South Asia and sub-Saharan Africa (Bibi, 2019; Farahmand, 2019). This finding underscores the importance of healthcare infrastructure and accessibility in addressing and mitigating infant mortality rates, particularly in resource-constrained settings like Nicaragua. It emphasizes the need for policies and interventions aimed at enhancing healthcare access and infrastructure to improve maternal and child health outcomes.

2. LITERATURE REVIEW

Ouattara et al. (2005) conducted a comprehensive study to investigate the impact of both private and public health expenditures on infant mortality across 160 countries, utilizing panel data to enhance the robustness of their findings. Their research methodology was meticulous, employing four distinct estimation techniques to ensure the reliability of the results. These techniques included the Ordinary Least Squares (OLS) method, Fixed Effects and Random Effects estimations, and the Generalized Method of Moments (GMM) technique, each offering unique insights into the data. The study's findings reveal a significant negative correlation between health expenditure and infant mortality rates, indicating that higher spending on health, whether private or public, is associated with lower rates of infant mortality. This outcome underscores the crucial role of health investment in improving child health outcomes and reducing infant deaths. Mamoon et al. (2011) conducted a study focusing on Pakistan, a country with a large population significantly contributing to its total production of goods and services. Recognizing the pivotal role of worker health in enhancing productivity, the study aimed to unearth the underlying causes of low health standards among the working population. Given the direct correlation between the health of the labor force and the overall production efficiency, identifying these root causes is crucial for devising strategies to improve health standards. By improving the health of workers, the study implies that Pakistan can achieve better growth in production, highlighting the need for targeted health interventions and policies that address the specific health challenges faced by the working population. This research not only sheds light on the critical issue of worker health but also suggests that improving health standards is a key factor in boosting the country's economic growth and productivity. Millard (1994) emphasizes the diverse

perspectives on child mortality distribution, particularly in developing countries where it has often been overlooked due to various factors such as cultural traditions related to child care, population pressures, low levels of maternal education, inadequate access to medical care, and scarce resources. Through research that took into account variables like child mortality rates, the level of maternal education, and the availability of primary health care, Millard concluded that child neglect and economic scarcity stand out as the primary causes of child mortality. This study sheds light on the complex interplay of socio-economic and cultural factors that contribute to child mortality, highlighting the importance of addressing economic and educational disparities, as well as enhancing access to health care, in order to mitigate these rates in developing nations. Hakro et al. (2007) examine the impact of government spending on health services in Pakistan, utilizing the benefit incidence approach to understand how such expenditures are distributed across different levels of healthcare, including maternal and child care, general hospitals, and clinics. Their analysis reveals a socioeconomic divide in healthcare utilization: lower-income groups are more inclined to use government hospital services, particularly for maternal care, due to the prohibitive costs of private maternal hospitals. Conversely, higher-income groups tend to prefer private hospitals, attracted by the higher quality of services offered. Furthermore, the study highlights regional disparities in the distribution of health expenditures, noting that at the provincial level, spending on maternal and child care in Punjab is highly regressive, indicating that the allocation of government health spending disproportionately benefits wealthier segments of the population, rather than equitably addressing the needs of all income groups. This research underscores the challenges of ensuring equitable access to healthcare services in Pakistan and the importance of targeted government intervention to support vulnerable populations.

The study by Hakro et al. (2007) reveals a significant disparity in healthcare spending across different income quintiles in Punjab, Pakistan, where the highest income quintile benefits nearly 8 times more from maternal and child care expenditures than the lowest income quintile. This stark contrast underscores the regressive nature of healthcare spending in Punjab, highlighting the inequitable distribution of government health resources, which disproportionately favors the wealthier segments of society. In contrast, the North-West Frontier Province (NWFP) demonstrates a more equitable, progressive approach to maternal and child care expenditures, suggesting that government spending in this area more effectively targets and benefits lower-income groups. Akram et al. (2007) note that numerous studies have utilized the Benefits Incidence Approach (BIA) to analyze household data, revealing disparities in the distribution of public expenditure benefits across various demographic and socio-economic groups. Gupta et al. (2002), drawing from data from 56 countries, found that higher public spending on health correlates with reduced mortality rates among infants and children. Butt et al. (2005) observed that socio-economic factors significantly influence healthcare expenditure in Pakistan, with the share of health expenditure in total public spending emerging as a critical variable impacting a country's health status. In Pakistan, the under-five child mortality rate stands at 101 deaths per 1,000 live births, and the country has a life expectancy of 62 years. As part of its commitment to global development and health improvement, Pakistan has aligned itself with the United Nations Millennium Development Goals (MDGs), established for the period from 2000 to 2014. The MDGs set forth 18 targets and 48 indicators to address a wide range of issues, including poverty reduction, education, gender equality, child mortality, maternal health, disease, environmental sustainability, and global partnership for development. Pakistan has adopted 16 of these targets and 37 of the indicators, signifying its dedication to achieving these internationally agreed-upon objectives to improve the well-being of its population and contribute to global development efforts.

Three of the eight Millennium Development Goals (MDGs) are directly related to the health sector, comprising four targets and sixteen indicators. Responsibility for public health service delivery in Pakistan is divided between the Ministry of Health at the federal level and health departments at the provincial levels. These entities are tasked with implementing policies, programs, and initiatives aimed at improving healthcare access, quality, and outcomes across the country. By focusing on these MDG-related health targets and indicators, Pakistan aims to address key health challenges, reduce

disease burden, improve maternal and child health, combat major diseases, and enhance overall population well-being. Reidpath et al. (2003) delve into the complexities surrounding the use of infant mortality rate as a measure of population health. While the infant mortality rate has traditionally been a key indicator in health policy, criticism has emerged regarding its narrow focus on a specific demographic group. Some argue that relying solely on proxy measures like infant mortality rate may overlook the health needs of older segments of the population. However, their study, drawing from data on infant mortality rates from the World Bank and the World Health Organization across 180 countries, finds little evidence to suggest that the emphasis on infant mortality disproportionately disadvantages other age groups. Instead, they assert that the infant mortality rate remains a vital indicator for understanding the overall health of populations, as it reflects broader structural factors that influence health outcomes across all age groups.

Meier et al. (1993) outline the methodology for defining the infant mortality rate, which is the number of deaths in children under 1 year of age per 1000 live births within the same year. Their study builds on previous research indicating that the availability of abortion and family planning services contributes to public health benefits. They note disparities in abortion rates, with non-White women experiencing a rate 2.7 times higher than that of White women, and highlight that Black women are more likely than White women to have unwanted births. The study focuses on two key variables: policies funding abortions for Medicaid-eligible women and policies funding family planning services for low-income women. The measure of abortion funding policy is the fund abortion rate, representing the number of publicly funded abortions per 1000 women aged 15 to 44 in the state. Per capita family planning expenditures encompass all federal and state funds allocated to such services.

Heshaw et al. (1994) emphasize the proliferation of agencies offering family planning services in the United States. According to their findings, approximately 2,614 agencies are engaged in providing these services, operating in at least 5,460 clinics nationwide. This represents a notable increase compared to the estimated 2,462 agencies and 5,174 clinics offering similar services in 1983. According to the findings, health departments operate around 52% of clinic sites, 15% of hospitals, and 27% of other agencies involved in providing family planning services. The majority of these agencies offer family planning services through separate clinic sessions dedicated specifically to this purpose. These clinics play a significant role in providing subsidized services to low-income women who do not qualify for Medicaid, thus ensuring access to essential healthcare services for vulnerable populations.

The study by Kazmi et al. (2009) delves into the disparities in resource allocation and healthcare delivery within the framework of government health expenditures. It underscores the heightened focus on human capital development in the new millennium, recognizing health as a crucial component of human development intricately intertwined with poverty alleviation and productivity enhancement. The research underscores the pivotal role of national health in fostering overall productivity and sustainable development, emphasizing the imperative of equitable resource allocation and healthcare provision to ensure comprehensive human development and societal well-being. The aim of this study is to examine the pattern of public sector spending in Pakistan's healthcare sector, utilizing primary data sourced from Pakistan. Conducted as an observational descriptive study between January and April 2008, the research draws on data from the PSLM Survey (Round 1) 2004-05, obtained from the Federal Bureau of Statistics, Government of Pakistan. The study focuses on analyzing the utilization of publicly provided health services, household income levels, and individual healthcare expenditures to gain insights into the dynamics of healthcare spending and its implications for public health outcomes in Pakistan.

Ude et al. (2014) conducted a study to examine the impact of per capita health spending on child mortality in Nigeria, utilizing secondary data spanning from 1980 to 2014. Their findings indicate that doubling public spending on healthcare from three to six percent of GDP would lead to a modest improvement in child mortality rates, estimated to be between nine to 13%. This suggests that while increased healthcare expenditure may have a positive effect on child mortality, the magnitude of this impact may be limited, emphasizing the need for comprehensive approaches to address child health

outcomes in Nigeria. In their study, Ude et al. (2014) employed ordinary least squares multiple regression analysis methods to investigate the association between healthcare expenditure and economic growth. Their findings revealed a significant and positive relationship between healthcare expenditure and economic growth. However, they noted that the results were not entirely consistent with those of previous research, indicating a need for synthesis and further exploration of the topic. Specifically, they highlighted discrepancies in how child mortality was analyzed, with some studies decomposing it into infant mortality, under-five mortality, and neonatal mortality rates. This suggests a nuanced understanding of the factors influencing child health outcomes is necessary for comprehensive policymaking and intervention strategies.

Zakir et al. (2010) emphasize the bidirectional relationship between infant mortality and fertility rate. They suggest that in countries with high population growth rates and where single mothers undergo multiple childbirths, overall health tends to be poorer, thereby increasing the likelihood of infant mortality. This underscores the interconnectedness of demographic factors and health outcomes, highlighting the importance of addressing both fertility rates and infant mortality rates in public health interventions and policy decisions. Agha (2000) utilized primary data from the Pakistan Integrated Household Survey (PIHS) to investigate factors associated with infant mortality in Pakistan. The study concluded that social indicators such as family poverty, parents' education levels, and access to sanitation facilities play significant roles in explaining the odds of infant mortality in the country. This underscores the importance of addressing socioeconomic factors and improving access to basic amenities in efforts to reduce infant mortality rates and improve overall child health outcomes in Pakistan.

Hassan et al. (2011) conducted a study to examine the prevalence of specific intrapartum practices in Sindh province aimed at identifying measures for safe delivery practices. Data were collected from 225 participants and 82 health workers using questionnaires. The researchers employed cross-sectional techniques in their study and concluded that there is a need for improvement in safe delivery practices and newborn care, particularly in rural areas. This suggests the importance of targeted interventions and improvements in healthcare infrastructure to enhance maternal and child health outcomes in the region. Millard (1994) categorizes the factors contributing to high child mortality rates into three tiers to provide context for understanding the medical causes of death and the discourse surrounding childcare practices. The first tier encompasses immediate biomedical conditions leading to death, often involving interactions between malnutrition and infections. This tier emphasizes the direct physiological factors contributing to child mortality, highlighting the critical role of addressing nutritional deficiencies and infectious diseases in reducing child deaths. In Millard's framework, the second tier comprises childcare practices and other behaviors that influence child mortality rates. This tier emphasizes the importance of caregiving practices, parental behaviors, and community norms in shaping child health outcomes. Moving beyond immediate biomedical factors, this tier highlights the role of social and behavioral determinants in influencing child mortality. The third tier encompasses broader social, economic, and cultural processes and structures that contribute to differential access to necessities such as food, shelter, and sanitation. These structural factors create the context within which childcare practices operate and interact with biomedical conditions, ultimately shaping child mortality rates. The research conducted in rural Mexico, Central America, and Africa provides empirical support for different aspects of Millard's model, particularly regarding traditional parental behaviors. These behaviors, often perceived as child neglect, are shown to be influenced by economic scarcity rather than intentional neglect. This highlights the complex interplay between economic factors and childcare practices in shaping child health outcomes. Additionally, the links between tiers in the model underscore the importance of understanding how factors at each level interact and influence child mortality rates. Further research and attention from both researchers and policymakers are needed to fully elucidate these interconnections and develop effective interventions to improve child health and well-being. Seshamani et al. (2004) address the significant issue of demographic change and its impact on future health expenditures, particularly in developed countries. The study specifically investigates how age

influences healthcare costs, employing statistical estimation techniques to analyze the relationship between demographic factors and healthcare expenditures. This research contributes to understanding the financial implications of aging populations on healthcare systems and can inform policy discussions aimed at ensuring sustainable healthcare financing in the face of demographic shifts. In their estimation, Seshamani et al. (2004) focus on individuals aged 65 and over as of the end of 1970. They utilize a longitudinal hospital dataset tracking 90,929 patients in this age group from 1970 until death. Using this data, they develop an economic model of hospital costs that incorporates patient age and the time remaining to death. Subsequently, they apply this model to population projections for England, spanning from 2002 to 2026, in order to forecast the impact of demographic changes on hospital expenditures. This approach allows them to assess how aging populations may influence healthcare costs over time, providing valuable insights for healthcare planning and policy-making.

The findings indicate that the decrease in age-specific mortality rates over time leads to a postponement of death to later ages. Meanwhile, Adam et al. (2000) delve into the costs and impacts of interventions aimed at achieving the health-related Millennium Development Goals. Their research equips policymakers with crucial insights to assess the allocation of resources toward maternal and nutritional health initiatives, aiding in the evaluation of current strategies and the formulation of more effective policies. The findings indicate that the decrease in age-specific mortality rates over time leads to a postponement of death to later ages. Meanwhile, Adam et al. (2000) delve into the costs and impacts of interventions aimed at achieving the health-related Millennium Development Goals. Their research equips policymakers with crucial insights to assess the allocation of resources toward maternal and nutritional health initiatives, aiding in the evaluation of current strategies and the formulation of more effective policies. Xu et al. (2003) conducted a study to assess the extent of catastrophic health expenditure and propose policy responses. Their research employed a cross-country analysis design, utilizing data from household surveys conducted in 59 countries. The study utilized bootstrap methods to calculate uncertainty intervals around the reported proportion of households experiencing catastrophic health expenditure. The findings revealed a positive relationship between the proportion of households facing catastrophic health expenditures and the share of out-of-pocket payments in total health expenditure.

Bhargava et al. (1990) conducted a study to examine the effects of health indicators, particularly adult survival rates (ASR), on economic growth rates over five-year intervals from 1965 to 1990 in both developed and developing countries. The study utilized panel data analysis on Gross Domestic Product (GDP) series adjusted for purchasing power and GDP series based on official exchange rates. In this study, two main objectives were pursued. Firstly, the researchers aimed to develop a framework to model the inter-relationships between GDP growth rates and explanatory variables, particularly re-evaluating the life expectancy-income relationship. Secondly, they conducted analyses on the stochastic properties of GDP series, employing classical tests for unit roots within a fixed-effects framework, alongside a dynamic random effects framework for testing. The findings underscored the significance of adult survival rates (ASR) on growth rates, particularly for poorer countries. Moreover, the study identified GDP thresholds beyond which ASR ceased to have a substantial impact on growth rates, with respective values obtained from PWT and WDI datasets.

3. DATA SOURCE AND MODEL

The study examines the relationship between health expenditure and infant mortality rate, using the data over the period 1975 to 2014. The data is collected from World Bank maintained databases like world development indicators (WDI) and the Economic Survey of Pakistan. The economic models are used to analyze and predict the relation/effects of the different variables in the economy. Prior studies have employed similar econometric strategies to evaluate social sector outcomes, particularly in relation to health and education in developing countries (Ali & Afzal, 2019; Ahmad, 2018). The economic model that is used in this paper includes infant mortality as a dependent variable and a log of the lady health visitor, a log of the rural health center, primary school enrolment, unemployment, and inflation as independent variables to investigate the relationship between infant mortality and

health expenditure in the case of Pakistan. Such modeling frameworks align with previous research that emphasizes institutional responsiveness and demographic challenges when analyzing health-related indicators (Khan, 2019; Kumar, 2018). The functional expression of the model is express as:
Infant mortality= f (Unemp, Lhw, Rhd, inf gdp, pe)
Unemp = unemployment
Lhw = lady health worker
Rhd = rural health development
Inf gdp = inflation gdp deflator
Pe = primary school enrollment

4. RESULTS

Table 1 reports the results of the unit root test conducted using the Augmented Dickey-Fuller (ADF) approach to assess the stationarity of the variables included in the model examining infant mortality as a function of unemployment (LUNE), lady health workers (LHV), rural health development (LRHC), inflation measured by GDP deflator (LINFGDP), and primary school enrollment (LPE). The logarithmic forms of the variables are used, as denoted by the "L" prefix. The t-statistic for LHV (log of lady health workers) is −4.512837 with a p-value of 0.0007, indicating strong statistical significance. The null hypothesis of a unit root is rejected at the 1% level, confirming that the series is stationary. LINFGDP (log of inflation using GDP deflator) has a t-statistic of −7.348921 and a p-value of 0.0000, showing very strong evidence of stationarity. This result indicates that inflation, as measured in this form, does not suffer from non-stationarity and is suitable for regression analysis without further transformation. The variable LINM, representing the log of infant mortality, has a t-statistic of −2.314206 and a p-value of 0.0042. While the t-statistic is lower in absolute terms compared to others, the p-value remains below the 1% level, confirming that infant mortality is also stationary. LPE (log of primary school enrollment) is clearly stationary as well, with a t-statistic of −6.190384 and a p-value of 0.0000. The high absolute value of the t-statistic and the zero probability strongly support rejection of the null hypothesis of a unit root. LUNE (log of unemployment) also passes the stationarity test convincingly, with a t-statistic of −7.558274 and a p-value of 0.0000, indicating the variable is well-suited for time series or panel estimation without further differencing. Lastly, LRHC (log of rural health development) has a t-statistic of −6.127401 and a p-value of 0.0000, again confirming stationarity at all conventional levels of significance. In summary, all the variables included in the functional model for infant mortality—LUNE, LHV, LRHC, LINFGDP, LPE, and LINM—are stationary at level, as evidenced by statistically significant ADF test statistics with p-values well below 0.01. This finding validates the direct use of these variables in regression modeling without the need for differencing or transformation, thus supporting robust statistical inference within a level form framework.

Table 1: Unit Root Results

Variable	t-Statistic	Probability
LHV	-4.512837	0.0007
LINFGDP	-7.348921	0.0000
LINM	-2.314206	0.0042
LPE	-6.190384	0.0000
LUNE	-7.558274	0.0000
LRHC	-6.127401	0.0000

Table 2 presents the results of the ARDL Bounds Testing Approach, which is used to determine whether a long-run relationship exists among the variables in the model. The key component of this test is the F-statistic, which is compared against the critical value bounds at different significance

levels. The variable K represents the number of independent variables in the model—in this case, K = 5.

The calculated F-statistic is 13.18274, which is significantly higher than the upper bound critical values (I1 Bound) at all conventional significance levels:

- At the 10% level, the lower and upper bounds are 2.31 and 3.42, respectively.
- At the 5% level, the bounds are 2.66 (I0) and 3.86 (I1).
- At the 2.5% level, the bounds are 3.01 and 4.27.
- At the most stringent 1% level, the critical bounds are 3.49 (I0) and 4.71 (I1).

Since the F-statistic of 13.18274 exceeds the upper bound at all levels, including the 1% level, the null hypothesis of no long-run relationship among the variables is rejected with strong statistical confidence. This indicates that the dependent variable—presumably infant mortality or its logarithmic form (LINM)—is cointegrated with its explanatory variables: unemployment (LUNE), lady health workers (LHV), rural health development (LRHC), inflation (LINFGDP), and primary school enrollment (LPE).

The presence of cointegration confirms the existence of a stable long-run equilibrium relationship among the variables, justifying the use of the ARDL model framework to estimate both short-run dynamics and long-run coefficients. Moreover, the strength of the F-statistic not only provides conclusive evidence of cointegration but also highlights the robustness of the long-run association in the model.

Table 2: ARDL Bound Test

Test Statistic	Value	K
F-statistic	13.18274	5
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.31	3.42
5%	2.66	3.86
2.5%	3.01	4.27
1%	3.49	4.71

Table 3 presents the co-integration results from the error correction model examining the long-run and short-run relationships between infant mortality and several explanatory variables: unemployment (LUNE), lady health workers (LLHV), rural health development (LRHC), inflation measured by the GDP deflator (LINFGDP), and primary school enrollment (LPE). The dependent variable is not explicitly named but is inferred to be infant mortality, and the model is designed to explore both dynamic (short-run) and equilibrium (long-run) effects.

The coefficient of the error correction term, Co-intEq(-1), is -0.0744 and is statistically significant (p = 0.0001), indicating the presence of a stable long-run relationship among the variables. The negative sign confirms convergence toward equilibrium, suggesting that about 7.4% of the deviation from the long-run equilibrium is corrected each period. This adjustment speed is relatively modest but statistically meaningful, affirming that the included variables jointly contribute to long-term changes in infant mortality (Engle & Granger, 1987).

In the short run, unemployment (LUNE) appears to have a mixed effect. The current difference (D(LUNE)) is negative but not significant (p = 0.2601), while its lag (D(LUNE(-1))) is negative and statistically significant (coefficient = -0.0032, p = 0.0098). This indicates that increases in unemployment have a delayed but harmful effect on infant mortality, likely due to reduced household income, access to healthcare, and overall well-being—factors that have been widely observed in public health research (Cutler et al., 2006).

Inflation (LINFGDP) exhibits a mixed pattern as well. The current value (D(LINFGDP)) is negative but insignificant (p = 0.1923), while its lag (D(LINFGDP(-1))) is positive and significant (coefficient = 0.0011, p = 0.0312). This counterintuitive lagged effect may reflect short-term price adjustments or fiscal responses that temporarily improve health funding or service delivery before inflation becomes destabilizing in the long term. The complexity of inflation's effect on health outcomes has been discussed in studies that differentiate between moderate and high inflation environments (Bremner et al., 2015).

The effects of lady health workers (D(LLHV)), rural health development (D(LRHC)), and primary school enrollment (D(LPE), D(LPE(-1))) are statistically insignificant, suggesting that in the short run, these factors do not produce measurable effects on infant mortality within the current specification. While intuitively these variables are expected to contribute positively, their impact may be more pronounced over longer periods or may be mediated by other structural conditions such as healthcare system capacity, maternal education, or nutrition, which are not explicitly captured in this model (Bhutta et al., 2005).

In conclusion, Table 3 provides evidence of a stable long-run relationship between infant mortality and the selected variables, with unemployment and inflation showing significant short-term influences, particularly in their lagged forms. The lack of short-run significance for health worker coverage, rural health development, and primary enrollment suggests that their effects are likely to manifest over time rather than immediately. The results reinforce the importance of sustained macroeconomic stability and employment generation for improving child health outcomes.

Table 3: Co-integration Results

Variable	Coefficient	Std. Error	t-Statistic	Probability
D(LLHV)	0.004192	0.005634	0.744037	0.4632
D(LPE)	-0.000093	0.002451	-0.037949	0.9701
D(LPE(-1))	0.002614	0.002226	1.174062	0.2456
D(LRHC)	0.008122	0.010129	0.801983	0.4290
D(LUNE)	-0.001389	0.001201	-1.156109	0.2601
D(LUNE(-1))	-0.003211	0.001145	-2.803544	0.0098
D(LINFGDP)	-0.000681	0.000509	-1.338139	0.1923
D(LINFGDP(-1))	0.001127	0.000492	2.291108	0.0312
Co-intEq(-1)	-0.074395	0.016834	-4.418926	0.0001

Table 4 presents the long-run coefficients estimated from the co-integrating relationship explaining the determinants of infant mortality, with the dependent variable implied to be infant mortality (in log form). The explanatory variables include lady health worker coverage (LLHV), primary school enrollment (LPE), rural health development (LRHC), unemployment (LUNE), and inflation measured via GDP deflator (LINFGDP). All coefficients are statistically significant at conventional levels, and their signs offer important insights into the long-term drivers of infant health outcomes.

The coefficient for LLHV is negative and highly significant (−0.2295, p = 0.0000), suggesting that an increase in the coverage of lady health workers leads to a substantial and statistically robust reduction in infant mortality. This finding reinforces the critical role of community-level female health providers in delivering maternal and child health services, especially in underserved or rural areas. Evidence from various countries, including Pakistan, has demonstrated that community health workers effectively reduce child mortality through immunization outreach, health education, and early disease detection (Hafeez et al., 2011).

Primary school enrollment (LPE) also shows a negative and statistically significant relationship with infant mortality (−0.0594, p = 0.0085). This indicates that improvements in educational attainment, especially among women, have long-term benefits for child health. Educated mothers are more likely

to adopt healthy practices, access medical care, and understand child nutrition and hygiene, thereby reducing mortality risk (Cleland & van Ginneken, 1988).

On the other hand, the coefficient for LRHC is positive (0.5471, p = 0.0000), which is counterintuitive, as one would expect rural health development to decrease infant mortality. However, this result may reflect issues of endogeneity, where rural health services are expanded in regions with historically high infant mortality rates. It may also indicate disparities in the quality or efficiency of healthcare delivery despite infrastructure development, suggesting that mere expansion of facilities does not always translate into better outcomes without adequate staffing, equipment, or outreach.

Unemployment (LUNE) has a positive and significant coefficient (0.0429, p = 0.0403), implying that higher unemployment is associated with increased infant mortality over the long term. This supports the view that economic insecurity reduces household access to food, healthcare, and essential services, adversely affecting child survival rates. Numerous studies have linked macroeconomic conditions to health, particularly in low-income settings where public safety nets are weak (Deaton, 2003).

Inflation measured by the GDP deflator (LINFGDP) has a negative and statistically significant coefficient (−0.0334, p = 0.0128), suggesting that higher inflation reduces infant mortality in the long run, which appears counter to conventional expectations. However, in some contexts, mild inflation may be a by-product of economic growth and increased government spending on health and social services. Alternatively, this may reflect improvements in income levels or service delivery that accompany periods of higher inflation, particularly in developing economies with demand-driven price increases (Bremner et al., 2015).

The constant term is positive and highly significant (4.5293, p = 0.0000), indicating the expected base level of infant mortality when all independent variables are at their means (in log terms).

In summary, the long-run results in Table 4 emphasize the crucial roles of lady health worker coverage and female education in reducing infant mortality, while highlighting the harmful effects of unemployment. The findings regarding rural health development and inflation require more contextual interpretation but suggest the need to look beyond infrastructure and consider service quality and economic dynamics more broadly.

Table 4: Long Run Coefficients

Variables	Coefficient	Std. Error	t-Statistic	Probability
LLHV	-0.229513	0.030118	-7.621054	0.0000
LPE	-0.059374	0.020792	-2.854002	0.0085
LRHC	0.547118	0.102764	5.324798	0.0000
LUNE	0.042871	0.019822	2.163927	0.0403
LINFGDP	-0.033418	0.012501	-2.673019	0.0128
C	4.529283	0.451219	10.034721	0.0000

5. CONCLUSIONS

The main objective of this paper is to assess the influence of health expenditure on infant mortality rates (IMRs). Alongside this primary aim, a secondary objective is to examine the impacts of five additional variables: the presence of lady health workers, rural health development initiatives, levels of unemployment, inflation rates, and primary school enrollment rates. Through this dual examination, the study aims to understand the various factors contributing to variations in IMRs, with a specific focus on the role of health expenditure and its interaction with socio-economic and healthcare-related factors. The study conducts a comprehensive analysis to draw conclusions about the relationship and impact of health expenditure on infant mortality rates in Pakistan. By rigorously analyzing health expenditure data alongside infant mortality rates, the research illuminates the

complex dynamics between healthcare investment and its outcomes in terms of infant survival. By clarifying this relationship, the study offers valuable insights to policymakers and stakeholders in the healthcare sector, assisting in the formulation of evidence-based strategies aimed at improving maternal and child health outcomes in Pakistan. Infant mortality serves as the dependent variable, while the logarithm of lady health workers, the logarithm of rural health development, unemployment rate, primary school enrollment rate, and inflation rate are considered as independent variables. Through statistical analysis, the research aims to estimate the effects of these independent variables on infant mortality rates. By examining the impact of factors such as healthcare workforce (lady health workers), rural health development initiatives, socioeconomic indicators (unemployment and primary school enrollment), and economic conditions (inflation), the study aims to identify the key determinants influencing infant mortality rates in Pakistan. The data used in the model consists of time series variables, and their stationarity is assessed using the Augmented Dickey-Fuller unit root test. The results indicate that all variables become stationary at the first difference. However, the independent variable shows significance only at the second difference. To estimate the variables and determine the presence of cointegration, the Autoregressive Distributed Lag approach is employed. Additionally, the Autoregressive Distributed Lag Bound test is conducted to confirm the existence of cointegration among the variables. This methodology facilitates the analysis of long-term relationships and dynamics between the independent and dependent variables in the model. This result suggests that there are long-term relationships among the variables in the model, enabling meaningful analysis of their interactions and effects over time.

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