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HEALTH CARE EXPENDITURE AND ITS IMPACT ON DEMOGRAPHIC INDICATORS IN INDIA: AN ECONOMETRIC ANALYSIS OF IMR, LER, AND BIRTH – DEATH DYNAMICS

Ashutosh Chhotaray [1] & Prof. Kabita Kumari Sahu [2]

RESEARCH ARTICLE

Author Details:
[1] Ph.D. Research Scholar, Maharaja Sriram Chandra Bhanja Deo University, Baripada, Odisha, India;
[2] Professor of Economics, Maharaja Sriram Chandra Bhanja Deo University, Baripada, Odisha, India

Corresponding Author:
Ashutosh Chhotaray

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Abstract

This study investigates the impact of health care expenditure on key demographic indicators in India specifically, Infant Mortality Rate (IMR), Life Expectancy Rate (LER), and birth–death dynamics – over the period 1994 to 2023. Using time-series econometric techniques, including the Augmented Dickey-Fuller (ADF) test and multiple linear regression analysis, the research evaluates the statistical significance and direction of influence of GDP growth, birth rate, and death rate on public health outcomes.

The ADF test results indicate that GDP growth is stationary at level, while most other demographic variables become stationary after first differencing. Regression results reveal that birth and death rates are significant predictors of both IMR and LER, whereas GDP growth does not have a statistically significant impact on these indicators. These findings suggest that demographic factors, rather than macroeconomic performance alone, play a more direct role in shaping population health outcomes. Stronger primary health care infrastructure and better access to essential services are essential for achieving long-term improvements in health indicators, advancing India's demographic transition, and achieving the Sustainable Development Goals (SDGs).

Keywords: *Health Care Expenditure; Infant Mortality Rate (IMR); Life Expectancy Rate (LER); Birth–Death Dynamics; Demographic Indicators; Public Health Spending; India; Population Health*

JEL CLASSIFICATION - I18, J11, C22, I15

Introduction

Spending on health care has a significant impact on a country's demographics and health. Public health spending is not only an economic investment but also a vital factor in human development in developing nations like India, where issues like poverty, population pressure, and infrastructure constraints present serious obstacles. India has seen both demographic and epidemiological changes over the last 30 years, with improvements in life expectancy, a notable drop in infant mortality, and declining birth and death rates. Despite these developments, regional and socioeconomic disparities in health outcomes still exist, which raises significant concerns about the efficiency and equity of health care spending.

Understanding the link between health care expenditure and demographic indicators such as the Infant Mortality Rate (IMR), Life Expectancy Rate (LER), and birth–death dynamics is essential for evidence-based policy formulation. While global studies suggest a strong relationship between public health investment and improved population health, the Indian context presents a complex scenario influenced by uneven development, fragmented service delivery, and varied state-level priorities.

This paper seeks to examine the impact of health care expenditure on key demographic indicators in India over the period 1994–2023 through an econometric lens. By focusing on IMR, LER, and birth–death trends, the study aims to evaluate whether increased public spending in health translates into tangible demographic gains. Employing time-series econometric methods, the paper also explores the nature of long-term equilibrium relationships and short-term adjustments between variables.

The findings of this research are expected to contribute to the growing discourse on health economics and demographic transition in India. They will also offer insights for policymakers striving to enhance the efficiency and effectiveness of public health financing in achieving Sustainable Development Goals (SDGs), particularly those related to good health and well-being.

Hypothesis to be tested:

Hypothesis No.	Relationship	Null Hypothesis (H_0)	Alternative Hypothesis (H_1)
Hypothesis 1	GDP Growth and Infant Mortality Rate (IMR)	GDP growth does not significantly affect IMR.	GDP growth has a significant negative effect on IMR.
Hypothesis 2	GDP Growth and Life Expectancy Rate (LER)	GDP growth does not significantly affect Life Expectancy.	GDP growth has a significant positive effect on Life Expectancy.
Hypothesis 3	Death Rate and Infant Mortality Rate (IMR)	Death rate has no significant effect on IMR.	Death rate has a significant effect on IMR.
Hypothesis 4	Current Health Expenditure (CHE as % of GDP) and Life Expectancy Rate (LER)	CHE as % of GDP has no significant effect on Life Expectancy Rate.	CHE as % of GDP has a significant positive effect on Life Expectancy Rate.

Health and Demographic Indicators in India

The following table presents time series data on key demographic and health indicators in India from the year 1994 to 2023. The selected indicators include Current Health Expenditure (CHE) as a percentage of GDP, life expectancy at birth (total), population growth rate, crude birth rate, crude death rate, sex ratio at birth, GDP growth rate, and infant mortality rate (IMR). These variables have been selected to analyze the relationship between economic growth and demographic changes, particularly focusing on the impact of health care expenditure (proxied through GDP growth) on life expectancy and infant mortality. The dataset allows for a comprehensive econometric analysis of how health outcomes evolve alongside macroeconomic performance and demographic trends. This data serves as the foundation for testing multiple hypotheses regarding the influence of economic and demographic variables on public health indicators in India.

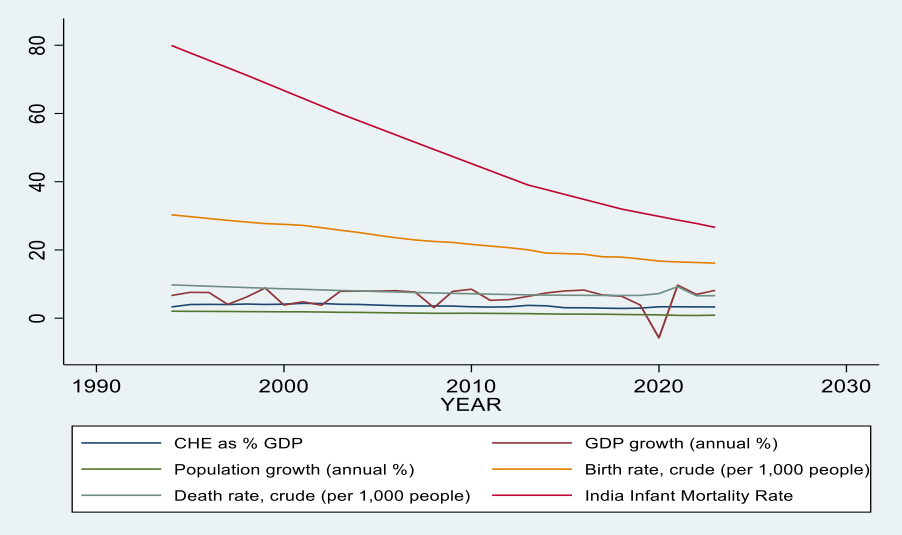
Table 1: Time Series Data on Health and Demographic Indicators in India (1994-2023)

Year	CHE (% of GDP)	Life expectancy at birth, total (years)	Population growth (annual %)	Birth Rate, crude (per 1,000 people)	Death Rate, crude (per 1,000 people)	Sex ratio at birth (male births per female births)	GDP growth (annual %)	India Infant Mortality Rate Per 1000 Live Births
1994	3.03	60.23	2.04	30.29	9.77	1.08	6.65	79.94
1995	4.00	60.63	2.01	29.77	9.57	1.08	7.57	77.76
1996	4.05	61.02	1.99	29.21	9.37	1.09	7.54	75.59
1997	4.01	61.43	1.96	28.68	9.17	1.09	4.04	73.42
1998	4.15	61.85	1.93	28.19	8.98	1.09	6.18	71.25
1999	4.02	62.28	1.09	27.73	8.08	1.09	8.84	68.99
2000	4.11	62.74	1.87	27.51	8.62	1.09	3.84	66.73
2001	4.34	63.15	1.87	27.02	8.48	1.09	4.82	64.47
2002	4.31	63.64	1.81	26.53	8.29	1.09	3.08	62.21
2003	4.08	64.08	1.73	25.78	8.12	1.09	7.86	59.95
2004	4.03	64.48	1.07	25.12	7.98	1.09	7.92	57.85
2005	3.84	64.93	1.63	24.03	7.81	1.09	7.92	55.76
2006	3.67	65.37	1.56	23.56	7.67	1.09	8.06	53.66
2007	3.58	65.08	1.05	22.93	7.53	1.09	7.66	51.56
2008	3.59	66.24	1.43	22.05	7.41	1.09	3.08	49.46
2009	3.55	66.07	1.44	22.21	7.29	1.09	7.86	47.38
2010	3.35	67.16	1.45	21.63	7.16	1.09	8.49	45.31

2011	3.25	67.62	1.41	21.15	7.04	1.09	5.24	43.23
2012	3.33	68.07	1.37	20.67	6.94	1.09	5.45	41.16
2013	3.75	68.49	1.33	20.06	6.85	1.09	6.38	39.08
2014	3.62	68.93	1.26	19.08	6.77	1.09	7.41	37.67
2015	3.06	69.32	1.19	18.93	6.72	1.09	7.99	36.25
2016	3.05	69.7	1.19	18.75	6.07	1.08	8.25	34.83
2017	2.94	70.06	1.16	17.99	6.67	1.08	6.79	33.42
2018	2.86	70.41	1.09	17.91	6.67	1.08	6.45	32
2019	2.95	70.74	1.04	17.36	6.67	1.08	3.87	30.92
2020	3.34	70.15	0.97	16.74	7.21	1.07	-5.77	29.85
2021	3.35	67.28	0.82	16.49	9.25	1.07	9.68	28.77
2022	3.31	71.69	0.79	16.33	6.57	1.07	6.98	27.77
2023	3.3	72	0.88	16.14	6.61	1.07	8.15	26.62
MEAN	**3.60**	**66.2**	**1.47**	**22.69**	**7.75**	**1.08**	**6.3**	**49.06**
SD	**0.43**	**3.54**	**0.38**	**4.57**	**1.03**	**0.007**	**2.85**	**16.16**
CV	**0.12**	**5.35**	**25.85**	**20.14**	**13.29**	**0.64**	**45.23**	**32.93**

Source: www.indiastat.com & World bank database

Figure 1: Trends in Population Growth and GDP Growth in India (1994–2023)



Source: Time series plot Author's computation using STATA

Methodology

Following techniques were applied to analyze the data for achieving the desired objective. These techniques are discussed below:

This study is based on secondary time series data for India spanning from 1994 onwards.

Objectives of the Methodology:

- To examine the relationship between economic growth and health indicators such as IMR and LER.
- To assess the role of health care expenditure in improving population health
- To test the statistical significance and direction of impact of GDP growth and demographic variables on IMR and LER.
- To check the stationarity of time series data and apply appropriate econometric models accordingly.

The methodology involves basic statistical measures such as mean, standard deviation, and coefficient of variation were calculated to understand the central tendency and dispersion of each variable. Testing the stationarity of the data series using the Augmented Dickey-Fuller (ADF) test to ensure the validity of econometric models. Based on the stationarity results, multiple linear regression models were applied to estimate the effect of GDP growth and demographic factors on IMR and LER. All

statistical analyses were conducted using STATA & EXCEL software, which facilitated the implementation of unit root tests, regression analysis, and model diagnostics.

Stationarity Test Results Using Augmented Dickey-Fuller (ADF) Method

To ensure the reliability of the time series analysis, we initially conducted unit root tests for each health and demographic indicator – namely, Infant Mortality Rate (IMR), Life Expectancy at Birth (LER), Birth Rate, and Death Rate – to examine their stationarity properties. The Augmented Dickey-Fuller (ADF) test was employed to determine whether the data series were stationary or contained unit roots.

Each variable's stationarity properties must be evaluated in order to guarantee the validity of time-series regression models. The Augmented Dickey-Fuller (ADF) test is employed to detect the presence of a unit root, indicating whether a variable is non-stationary over time. Stationary variables are a prerequisite for avoiding spurious regression and ensuring reliable inferences in time series econometrics.

In this study, ADF tests were conducted on all major variables, including GDP growth, birth rate, death rate, infant mortality rate (IMR), life expectancy rate (LER), and population growth. The test was applied at level and, where necessary, at first difference.

Table 2: Augmented Dickey-Fuller (ADF) Unit Root Test Results (Trend Included, Lag = 1)

Variable	ADF Test Statistic (Z(t))	1% Critical Value	5% Critical Value	10% Critical Value	p-value	Stationary at Level?
Birth Rate (Crude)	-0.672	-4.352	-3.588	-3.233	0.9749	No
Death Rate (Crude)	-2.459	-4.352	-3.588	-3.233	0.3489	No
CHE % of GDP	-2.490	-4.352	-3.588	-3.233	0.3330	No
GDP Growth (Annual %)	-3.954	-4.352	-3.588	-3.233	0.0102	Yes (at 10%)

- The null hypothesis of a unit root is rejected only for GDP growth at the 10% significance level, indicating it's stationary at level.
- All other variables fail to reject the null hypothesis at conventional levels, suggesting they are non-stationary at level.
- These variables may need to be differenced before regression or included in models like ARDL/cointegration frameworks if appropriate.

Table 3: ADF Unit Root Test Results (First-Differenced Variables)

Variable	ADF Test Statistic (Z(t))	1% Critical Value	5% Critical Value	10% Critical Value	p-value	Stationary?
Birthrate	-3.596	-4.362	-3.592	-3.235	0.0302	Yes
Deathrate	-6.515	-4.362	-3.592	-3.235	0.0000	Yes
CHE as GDP	-4.407	-4.362	-3.592	-3.235	0.0021	Yes
GDP growth	-5.660	-4.362	-3.592	-3.235	0.0000	Yes

All variables become stationary after first differencing, indicating they are integrated of order one (I (1)).

Regression Results and Analysis

To investigate the relationship between Infant Mortality Rate (IMR) and key economic and demographic factors, including health spending, an Ordinary Least Squares (OLS) regression model was estimated. The model includes GDP Growth, Birth Rate, Death Rate, and Current Health Expenditure as % of GDP (CHE as% of GDP).

Regression of IMR on GDP Growth, Birth Rate, Death Rate and CHE as % of GDP

Model 1: $IMR_t = \alpha + \beta 1(GDP\ Growth)_t + \beta 2(Birth\ Rate)_t + \beta 3(Death\ Rate)_t + \beta 4(CHE\ as\ \%\ of\ GDP)_t + \varepsilon_t$

Variable	Coefficient	Std. Error	t-Statistic	p-Value
Intercept	-34.2808	1.9072	-17.9749	8.25E-16
GDP growth (annual %)	-0.0437	0.0630	-0.6934	0.4944
Birth rate (per 1,000 people)	3.5674	0.0828	43.0784	< 0.00001
Death rate (per 1,000 people)	1.1815	0.3043	3.8829	0.0007
CHE as % of GDP	-1.5163	0.6530	-2.3221	0.0287

Regression Statistics:

- R Square = 0.9972 (99.72% of the variation in IMR is explained by the predictors)
- Adjusted R Square = 0.9960 (Adjusted for number of predictors, still excellent)
- Standard Error = 0.9581(Low average error of the prediction)
- Observations = 30
- F-statistic = 2235.99
- Significance F = 1.56381E-31

➢ Birth rate and death rate are highly significant predictors of IMR.
➢ CHE as % of GDP is statistically significant and negative, indicating that higher public health spending reduces IMR.
➢ GDP growth has a negative but statistically insignificant effect on IMR, suggesting that economic growth alone does not directly reduce infant mortality without targeted interventions.

For LER: Model 2

$$LER_t = \alpha + \beta 1(GDP\ Growth)_t + \beta 2(Birth\ Rate)_t + \beta 3(Death\ Rate)_t + \beta 4(CHE\ as\ \%\ of\ GDP)_t + \varepsilon_t$$

Variable	Coefficient	Std. Error	t-Statistic	p-Value
Intercept	87.9107	0.7497	117.26	0.0000
GDP Growth (annual %)	-0.0199	0.0248	-0.81	0.4273
Birth Rate (per 1,000 people)	-0.5270	0.0326	-16.19	0.0000
Death Rate (per 1,000 people)	-1.1308	0.1196	-9.45	0.0000
CHE as % of GDP	-0.2359	0.2567	-0.92	0.3668

Regression Statistics:

- R Square = 0.990
- Adjusted R Square = 0.989
- Standard Error = 0.376671
- Observations = 30
- F-statistic = 634.14
- Significance F = 9.87135E-25

➢ Birth rate and death rate have a strong and statistically significant negative impact on life expectancy in India.
➢ GDP growth and health expenditure (CHE as % of GDP) show no significant effect on life expectancy.
➢ The model has an excellent fit ($R^2 = 0.990$), explaining 99% of the variation in life expectancy.

Suggestions

Based on the econometric analysis conducted in this study, the following suggestions are proposed to guide future policy formulation and public health investment in India:

1. **Prioritize Targeted Health Interventions Over General Economic Growth**: The regression analysis shows that GDP growth has no statistically significant effect on IMR or LER. This demonstrates that economic growth alone does not ensure better health outcomes. As a result, policymakers should prioritize direct investments in health services, particularly maternal and child health, rather than relying solely on economic growth to improve public health.
2. **Strengthen Efforts to Reduce Birth and Death Rates:** Birth and death rates were identified as highly significant predictors of both IMR and LER. This emphasizes the importance of continuing to invest in reproductive health programs, expanding access to family planning services, and institutionalizing deliveries. Public awareness campaigns and improved mortality surveillance systems are also required to alleviate demographic pressure on the healthcare system.
3. **Enhance Efficiency and Effectiveness of Health Spending:** Current Health Expenditure (CHE as a percentage of GDP) was statistically significant for IMR but not for LER. This suggests that increased spending does not always result in improved outcomes. Improving fund allocation efficiency, targeting underserved areas, and increasing accountability in

health infrastructure are critical to maximizing the benefits of public spending. Enhance primary healthcare infrastructure and services.

4. **Build and Strengthen Primary Healthcare Infrastructure:** Expanding primary healthcare services, especially in rural and remote areas, is vital for preventive care and reducing avoidable deaths. Investments should focus on nutrition programs, immunization coverage, skilled birth attendance, and early childhood interventions, which directly influence both IMR and LER.
5. **Promote Real-Time Data Monitoring and Policy Feedback:** The ADF test results indicate that many variables are non-stationary at level, implying the importance of long-term trends. To address this, policymakers should utilize real-time health data systems and forecasting models for evidence-based planning, dynamic strategy adjustments, and effective monitoring of health outcomes.

The study's findings suggest that India should shift its health policies away from macroeconomic growth and toward more tailored, evidence-based strategies that address demographic and public health needs. The significant impact of birth and death rates on infant mortality and life expectancy emphasizes the importance of improving reproductive health services, mortality-reduction strategies, and overall primary healthcare infrastructure. Furthermore, while health expenditure (CHE as a percentage of GDP) has some influence, its inconsistent significance emphasizes the importance of how funds are used rather than the amount spent. To ensure long-term improvements in population health, new health policies should prioritize efficiency, accessibility, and fairness in resource allocation.

Conclusion

This study examined the relationship between health-care expenditure and key demographic indicators in India from 1994 to 2023, specifically the Infant Mortality Rate (IMR), Life Expectancy Rate (LER), and birth and death rate dynamics. Using time-series econometric tools such as Augmented Dickey-Fuller (ADF) tests and multiple linear regression models, the analysis provides strong insights into how macroeconomic and demographic variables influence public health outcomes.

The empirical findings show that the birth and death rates are statistically significant predictors of both IMR and LER, confirming demographic factors' central role in shaping population health. In contrast, GDP growth has no significant direct impact on either health indicator, implying that macroeconomic progress does not always result in better health outcomes. Similarly, Current Health Expenditure (CHE) as a percentage of GDP has mixed effects, with a statistically significant reduction in IMR but no improvement in LER, indicating that health spending effectiveness and targeting are critical.

The findings highlight the importance of policy shifts towards direct public health interventions, particularly in maternal and child health, family planning, and mortality reduction. Investments in primary healthcare infrastructure, preventive care, and health system efficiency are critical for achieving long-term improvements in life expectancy and infant survival. Furthermore, the study emphasizes the significance of utilizing real-time data and long-term monitoring to support evidence-based policymaking.

In conclusion, while economic growth creates a favorable environment, demographic management and efficient health-care spending are the valid controls for improving public health in India. These findings are critical for coordinating national health policy with the Sustainable Development Goals (SDGs), specifically Goal 3: Good Health and Well-Being.

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