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Evaluating the Impact of Health Infrastructure on Health Outcomes in Rural Uttar Pradesh

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Abstract

This study examines the relationship between health infrastructure and health outcomes in rural Uttar Pradesh from 2005 to 2022 through regression analysis and composite indices. It evaluates sub-centres, primary health centres, community health centres, government hospitals, and hospital beds as indicators of health infrastructure, alongside birth rate, death rate, and infant mortality rate for health outcomes. These variables have been incorporated using composite indices of Health Infrastructure and Health Outcomes (CHI and CHO) and standardized using min-max scaling. The findings demonstrate a significant positive impact of improved health infrastructure on health outcomes, explaining 82.4% of outcome variation. This study highlights that enhanced healthcare access and better-quality services are crucial for fostering improved health outcomes in rural communities.

Keywords: Health Infrastructure, Health outcomes, Regression Analysis, Composite indices

Introduction

A strong healthcare system's foundation is its health infrastructure, which is essential to achieving desired health results. A variety of elements are included in it, including medical equipment, healthcare workers, hospitals, clinics, and basic healthcare facilities. The lack of access to healthcare resources and services in rural areas makes health infrastructure even more crucial. Because rural residents in Uttar Pradesh, the most populous state in India, have particular difficulties getting access to high-quality medical care, building and maintaining a health infrastructure is crucial to enhancing patient outcomes. Health outcomes in rural Uttar Pradesh have historically been poor due to high incidence of infectious illnesses and infant and maternal mortality. These results show where the rural population's access to high-quality healthcare services is lacking. The health and wellbeing of people are negatively impacted by the fact that many healthcare institutions lack basic amenities, skilled staff, and necessary medical equipment.

Rural India often faces challenges such as insufficient healthcare facilities, a shortage of medical personnel, and inadequate medical supplies, all of which contribute to poor health outcomes. In order to better understand the impact of rural infrastructure on rural development, the article by Ghosh (2017) evaluated the current status of rural infrastructure in India. The findings of this study indicate that a number of infrastructural indicators were critical to the advancement of rural development. According to the findings, the government should focus on raising infrastructure spending in order to raise life expectancy, improve literacy rates, lessen poverty, and decrease newborn mortality rates, which was essential for overall rural development. As analysed by Hati and Majumdar (2013), In densely populated states, the existing health infrastructure was found to be inadequate, leading to reduced quality of healthcare and increased mortality risk. Good health had been shown to contribute significantly to positive outcomes such as demographic benefits, a more productive workforce, and poverty reduction by increasing people's earning potential. Due to the variability in health facilities and their strong connection to health outcomes and overall development, several measures had been recommended. For efficient preventative and curative treatments to be provided at the local level, primary healthcare facilities needed to be strengthened. This would have lessened the strain on secondary and higher institutions. Furthermore, it was mentioned that there was an immediate need for more workers, especially in rural areas. The study by Lakshmi and Sahoo (2013) aimed to determine the elasticity coefficients of health outcomes in connection to health infrastructure in Andhra Pradesh, a progressive state in India. The number of doctors, hospitals, and clinics, as well as the number of beds in government hospitals, were among the variables that the researchers used to build an index of health infrastructure. The results of the double log simple regression analysis showed that health indicators were significantly and favourably impacted by health infrastructure. But the study found that improving health outcomes required more than just building a strong health infrastructure. The efficacy of health infrastructure was primarily contingent upon its operational efficiency, appropriate execution, consistent upkeep, and efficient allocation of the state's resources. The development of health infrastructure and its effects on health outcomes and economic growth in the major Indian states were examined in this study by Varkey, Joy, and Panda (2020). It was discovered that there

was a negative association with infant mortality and a positive correlation with life expectancy, economic growth, and the health infrastructure index. Improved health and economic results were linked to improvements in health infrastructure, as demonstrated by state-level analysis that validated these correlations. The findings of the research by Majumder, Roy, Bose, and Chowdhury (2023) showed a direct correlation between socioeconomic position and the healthcare system, which affects access to high-quality medical care in the state of west Bengal. As areas advanced, so did their healthcare systems, which helped marginalized groups. However, inadequate basic healthcare facilities, a lack of competent healthcare professionals, and limited funding all contributed to the poor quality of healthcare in West Bengal. To improve the healthcare ecosystem, increased infrastructure and medical facilities alone were insufficient. In contrast, considerable progress in health infrastructure has been made in other Indian states, such as Kerala, Tamil Nadu, and Maharashtra, leading to improved health metrics. These states have made significant investments in the construction and upkeep of healthcare facilities, the education of medical professionals, and the guarantee of the availability of necessary medical supplies. As a result, individuals experience improved overall health outcomes, increased life expectancy, and decreased newborn mortality rates. The differences between these states and Uttar Pradesh highlight how urgently concentrated efforts to improve the state's poor rural health infrastructure are needed.

This research paper aims to analyse the relationship between health infrastructure and health outcomes in rural Uttar Pradesh from 2005 to 2022. Using regression analysis and secondary data sources, the study will explore how improvements in health infrastructure have influenced key health indicators. The study employs a simple regression model using Composite Indices. The findings will provide crucial insights for policymakers and healthcare providers to design and implement effective strategies to improve health outcomes in rural Uttar Pradesh.

Objectives

1. To identify the availability and quality of Health Infrastructure in Rural Uttar Pradesh.
2. To assess the Health Outcomes in Rural Communities of Uttar Pradesh.
3. To evaluate and understand the relationship between the health infrastructure and health outcomes.

Status of Health Infrastructure and Health Outcomes in Rural Areas of Uttar Pradesh

The relationship between health infrastructure and health outcomes is a crucial area of study, especially in rural regions where access to healthcare services can be limited. With a significant portion of its population residing in rural areas, the health outcomes of Rural areas of Uttar Pradesh are heavily influenced by the availability and quality of its health infrastructure. Over the past two decades, Uttar Pradesh has seen substantial efforts to improve its health infrastructure. This period has been marked by significant investments in healthcare facilities, including sub-centres, primary health centres (PHCs), community health centres (CHCs), and government hospitals. These efforts aim to provide better access to essential health services for the rural population, which has historically faced challenges such as limited healthcare access, poor health outcomes, and high rates of mortality and morbidity.

Table 1: Health Infrastructure of Uttar Pradesh (Rural)

Year	Sub Centres (SCs)	Primary Health Centres (PHCs)	Community Health Centres (CHCs)	Number of Government Hospitals	Number of beds in Govt. Hospitals
2005	18577	3640	294	294	8820
2006	20521	3660	386	397	11910
2007	20521	3660	386	397	11910
2008	20521	3690	515	397	11910
2009	20521	3690	515	397	11910
2010	20521	3692	515	515	15450
2011	20521	3692	515	515	15450
2012	20521	3692	515	515	15450
2013	20521	3496	773	515	15450
2014	20521	3497	773	515	15450
2015	20521	3497	773	737	23400
2016	20521	3497	773	780	23400
2017	20521	3621	822	780	23400
2018	20521	3621	822	821	39104
2019	20782	2936	679	821	39104
2020	20778	2880	711	1595	40130
2021	20778	2923	753	1595	40130
2022	20781	2919	829	1626	42698

Source: National Health Profile, Central Bureau of Health Intelligence, Ministry of Health and Family Welfare; Rural Health Statistics, Ministry of Health and Family Welfare; and Sample Registration System (SRS) Statistical Report, Ministry of Home Affairs.

Table 1 presents the health infrastructure of rural areas in Uttar Pradesh from 2005 to 2022. The indicators used to represent health infrastructure are sub-centres (SCs), primary health centres (PHCs), community health centres (CHCs), government hospitals, and the number of beds in government hospitals. Sub-centres (SCs) are the small healthcare units providing basic medical services and maternal and child health care. The number of sub-centres had steadily increased over the period, reflecting efforts to expand basic healthcare services and improve access to maternal and child health care in rural areas. Primary Health Centres (PHCs) offers primary healthcare, preventive services, and limited inpatient care. Initially, the number of PHCs increased, indicating a focus on expanding primary healthcare services. However, a decline in the number of functioning PHCs was observed from 2019, possibly due to resource reallocation, maintenance issues, or administrative changes. Community Health Centres (CHCs) are the larger health facilities providing specialist care and more extensive medical services. CHCs had shown a consistent increase throughout the period, demonstrating a commitment to enhancing specialist care and providing more extensive medical services to rural populations. The number of government hospitals (GOVT_HOSP) had significantly increased from 294 in 2005 to 1,626 in 2022. This substantial growth indicates a major investment in expanding comprehensive medical care facilities in rural areas. As the number of government hospitals increased, the number of beds (GOVT_BEDS) also rose, ensuring that the growing demand for inpatient

care can be met. Overall, there was an increasing trend in the health infrastructure indicators, reflecting significant improvements in the availability and capacity of healthcare facilities in rural Uttar Pradesh.

The Composite index of Health Infrastructure (CHI) was estimated to represent the overall health infrastructure, combining the weighted values of each indicator to reflect their relative importance (Table 3). All the variables were standardized to a common scale using min-max scaling before calculating the composite index. Thus, CHI was constructed as follows:

$$CHI = (0.1 \times SC) + (0.2 \times PHC) + (0.3 \times CHC) + (0.3 \times GOVT\_HOSP) + (0.1 \times GOVT\_BEDS)$$

Table 2: Health Outcomes of Uttar Pradesh (Rural)

Year	Birth Rate	Death Rate	Infant Mortality Rate
2005	31.3	9.1	77
2006	31	9.1	75
2007	30.5	9	72
2008	30	8.8	70
2009	29.7	8.8	66
2010	29.2	8.5	64
2011	28.8	8.3	60
2012	28.4	8.1	56
2013	28.1	8.1	53
2014	28.3	8	51
2015	27.9	7.7	48
2016	27.3	7.3	46
2017	27	7.2	44
2018	26.6	7	46
2019	26.4	6.9	44
2020	26.1	6.8	40
2021	25.5	6.6	35
2022	25.2	6.4	33

Source: Rural Health Statistics, Ministry of Health and Family Welfare

Table 2 represents the health outcomes of rural areas in Uttar Pradesh from 2005 to 2022, using birth rate, death rate, and infant mortality rate as indicators. Birth Rate (BR) shows the number of live births per 1,000 people per year. The birth rate had decreased from 31.3 in 2005 to 25.2 in 2022. This decline can be attributed to improved family planning services, increased use of contraceptives, and better education and awareness about reproductive health. The annual number of deaths per 1,000 persons is known as the death rate (DR).

The death rate had decreased from 9.1 in 2005 to 6.4 in 2022. Factors contributing to this reduction include better access to healthcare facilities, improved medical treatments, enhanced nutrition, and better management of communicable and non-communicable diseases. Infant Mortality Rate (IMR) represents the number of infant deaths (under one year of age) per 1,000 live births. The IMR had dropped significantly from 77 in 2005 to 33 in 2022. This improvement is likely due to better maternal and child healthcare services, increased immunization coverage, improved prenatal and postnatal care, and greater efforts to prevent and treat common childhood illnesses. Overall, the decrease in these rates shows significant improvement in the health sector of rural Uttar Pradesh.

The Composite index of Health Outcomes (CHO) was estimated to represent the overall health outcomes, combining the weighted values of each indicator to reflect their relative importance (Table 3). Firstly, DR and IMR was converted into their reciprocals so that higher values indicate better health outcomes. Here, BR was considered as a negative variable due to potential overpopulation issues present in rural areas. All the variables were then standardized to a common scale using min-max scaling before calculating the composite index. Thus, CHO was constructed as follows:

$$CHO = (0.3 \times BR) + (0.3 \times DR) + (0.4 \times IMR)$$

Table 3: Composite Indices

Year	Composite Health Infrastructure Index (CHI)	Composite Health Outcomes Index (CHO)
2005	0.187	0
2006	0.364	0.020
2007	0.364	0.061
2008	0.444	0.108
2009	0.444	0.141
2010	0.481	0.200
2011	0.481	0.261
2012	0.481	0.327
2013	0.578	0.365
2014	0.578	0.382
2015	0.652	0.462
2016	0.661	0.559
2017	0.719	0.610
2018	0.775	0.634
2019	0.538	0.682
2020	0.719	0.765
2021	0.753	0.911
2022	0.810	1

Source: Author's calculation

Table 3 shows the Composite Health Infrastructure Index (CHI) and Composite Health Outcomes Index (CHO). Since the values of composite index are between 0 and 1 where a consistently high value which is close to one indicates improved availability of infrastructure and sustained good health outcomes over time. Whereas a consistently low value, close to zero, indicates insufficient health infrastructure and persistent poor health outcomes. Overall, an increasing trend on both the indices shows improvement in health infrastructure as well as health outcomes.

Table 4: Regression Analysis

Independent Variables	Coefficients	Significance
Intercept	-0.509	0.000316
CHI	1.659	1.98E-07
Multiple R	0.908	
R Square	0.824	
Standard Error	0.133	

Source: Author's calculation

Table 4 gives the results of Regression statistics. The correlation coefficient, Multiple R (0.908) indicating a strong positive linear relationship between health infrastructure (CHI) and health outcomes (CHO). R Square (0.824) shows that approximately 82.4% of the variability in health outcomes can be explained by the health infrastructure variable. Standard Error (0.133) measures the typical distance that the observed values fall from the regression line. When Standard Error is smaller, it shows better fit.

The intercept (-0.509) represents the expected value of the health outcomes when the health infrastructure is zero. A negative intercept value suggests that without any health infrastructure, the health outcomes are poor. The coefficient for the health infrastructure (CHI) variable indicates that for every one unit increase in health infrastructure, the health outcomes (CHO) improve by 1.659 units. This shows that better health infrastructure leads to better health outcomes. This happens because better infrastructure in rural areas of Uttar Pradesh provides better quality of care with advanced equipment and trained staff, easier access to healthcare services, effective preventive measures like vaccinations and maternal care, and timely emergency services. The p-values are much smaller than 0.05, indicating that both the intercept and the infrastructure coefficient are statistically significant.

Conclusion

The regression model shows that better health infrastructure significantly improves health outcomes in Rural Uttar Pradesh. The infrastructure has a strong positive impact, explaining 82.4% of the variation in health outcomes. This means that access to healthcare services, better quality care, preventive measures, emergency services, and improved living conditions all contribute to better health when infrastructure is improved. This underlines the importance of investing in health facilities, services, and human resources in the rural areas of Uttar Pradesh to achieve better health standards.

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