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# A State Wise Analysis of Infectious Disease Rates in India

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**Abstract—***Background Infectious diseases have significantly impacted Human Morbidity and Mortality Rates, and have led to much economic adversity in India. They are a significant deterrent to socio-economic growth and cause extreme financial distress, especially in low-income households. This paper sets out to mathematically analyse the dependence of case rates of common infectious diseases on several aspects of state infrastructure, which may influence disease instances. The results of this analysis of these factors can be implemented for better disease control in our country.*

*Methods This mathematical analysis was done using Multivariable Linear Regression on raw time series data to investigate the dependence of infectious diseases case rates on various aspects of state infrastructure from 2008 to 2015. In addition, Karl Pearson's Correlation was carried out between the dependent variable and the independent variables (both as One-way Analysis and Two-way Analysis). This was followed by Cross-Correlation analysis between the independent variables to eliminate factors that would point to the same result.*

*Results This study highlights the high dependence of Normalised Case Rate of Infectious Diseases on state-wise Expenditure on Healthcare, Birth Rate, Poverty Rate and Literacy Rate. In addition, it is nearly independent of the number of Rural Primary Healthcare Centers and the number of Government Hospitals in each state.*

## 1. Introduction

### 1.1 Background

Infectious diseases over the years have significantly impacted Human Morbidity and Mortality Rates, and have led to much economic adversity in India. The need to study these diseases can be highlighted by the fact that 52% of the 20 lakh confirmed malaria cases in South-East Asia were contributed by India[1]. India reported 99 thousand dengue cases and 220 deaths during the year 2017[2]. Infectious diseases are a significant deterrent to socio-economic growth. In addition, these diseases cause extreme financial distress, especially in low-income households, since they are expensive to treat and prevent patients from earning income. This has led to the launch of several government schemes like RSBY[3] and the PMJAY[4] to alleviate the effects of these diseases by providing people with health insurance. Another method of preventing diseases from distressing people is to reduce the cost of treatment of these diseases. It is of utmost importance to take steps to prevent infectious diseases from spreading.

### 1.2 Aim

This paper sets out to mathematically analyse the dependence of case rates of common infectious diseases on several aspects of state infrastructure, which may influence disease instances. This mathematical analysis was done using Correlation Analysis as well as Linear Regression analysis. Regression analysis is among the most commonly used methods of statistical analysis, especially in public health research. It is used to describe the dependence of a particular variable that is being studied on several explanatory variables. Correlation is a type of analysis in two variables that measures the relationship between two variables and the direction of the association between them.

The four most common infectious diseases in India, are Malaria, Acute Diarrhea, Acute Respiratory Infection and Viral Hepatitis, have been discussed in this paper which sets out to determine the factors affecting the state-wise case rate of the above mentioned communicable diseases in India. This was done using traditional time-series regression on particular medical factors to evaluate the case rate and mortality of these infectious diseases. In addition, Karl Pearson's Correlation was carried out between the dependent variable and the independent variables (both as One-way Analysis and Two-way Analysis), followed by

[1] World Malaria Report, 2013
[2] Dengue In India - World Health Organisation, 2018
[3] Rashtriya Swasthya Bima Yojana
[4] Pradhan MantriAyushman Bharat Yojna

Cross-Correlation analysis between the independent variables to eliminate factors that would point to the same result. Regression has been done on raw time series data to investigate the dependence of infectious diseases case rates on various aspects of state infrastructure. This mathematical analysis of the disease rates confirms the dependence of the case rate of these diseases on various factors. The results of this analysis of these factors can be implemented for better disease control in our country.

### 1.3 Tools used in this analysis

The package R 2.9.0 has been used to carry out Multivariable Linear Regression Analysis as well as Cross-Correlation Analysis on the independent variables. For all other graphical and mathematical analysis and modelling, including Simple Linear Regression and bivariate Correlation Analysis, Microsoft Excel 2013 was used.

## 2. Estimation and Causal Analysis

### 2.1 Factors and Sources

1. Diseases: Cases and Deaths - Directorate General of State Health Services
2. State Expenditure on healthcare - Budget documents of the state governments, CAG for 2015-16 in respect of Jammu & Kashmir
3. Literacy Rate - data.gov.in
4. State per capita GDP - Ministry of Statistics and Programme Implementation
5. Estimated birth rates, death rates and Infant Mortality Rate - data.gov.in
6. The Population of States - Office of the Registrar General of India, Ministry of Home Affairs
7. Number of Government Hospitals, Allopathic Doctors and Hospital Beds - Directorate General of State Health Services
8. Rural Health Infrastructure - Ministry of Health & Family Welfare
9. Literacy Rate - NITI Aayog[5]
10. Poverty Rate - Reserve Bank of India, Census Sept 16 2015

### 2.2 Results of Correlation Analysis

The results of Karl Pearson's Correlation carried out on these variables[6] state-wise are:

1. The Normalised Case Rate of Infectious Diseases has a strong correlation with Birth Rate and Infant mortality rate and a moderate negative correlation with Mortality Rate.
2. The Normalised Case Rate of Infectious Diseases has a powerful correlation with State Expenditure towards Healthcare.
3. The Normalised Case Rate of Infectious Diseases has a moderate negative correlation with State per capita GDP
4. The Normalised Case Rate of Infectious Diseases has a weak positive correlation with the number of Government Hospitals, Hospital Beds and Doctors
5. The number of Government Hospitals, Hospital Beds and Doctors has a strong positive correlation with State Expenditure towards Healthcare
6. The number of Government Hospitals, Hospital Beds and Doctors has a weak positive correlation with State per capita GDP
7. Infant Mortality Rate has a moderate negative correlation with State Expenditure towards Healthcare
8. The number of rural Primary Healthcare Centres has a strong positive correlation with State Expenditure towards Healthcare
9. The Normalised Case Rate of Infectious Diseases has a moderate negative correlation with Literacy Rate.
10. The Normalised Case Rate of Infectious Diseases has a strong positive correlation with Poverty Rate
11. As the State per capita GDP increases, State Expenditure on Healthcare increases, and this causes a decrease in the Normalised Case Rate of Infectious Diseases.
12. As the State per capita GDP increases, the state-wise Number of Government Hospitals increases, and this causes a decrease in the Normalised Case Rate of Infectious Diseases.

[5] National Institution for Transforming India
[6] This was done using Excel

13. As State per capita GDP increases, the number of Doctors per Government Hospitals increases and the Normalised Case Rate of Infectious Diseases decreases.
14. As the State Poverty Rate decreases, the number of Government Hospitals increases, and the Normalised Case Rate of Infectious Diseases decreases.
15. As the number of Doctors per Government Hospital increases, the number of Hospital Beds per Hospital in a state increases, and the Normalised Case Rate of Infectious Diseases decreases.

### 2.3 Cross Correlation Analysis

Using Cross-Correlation[7], eight independent variables were selected for Regression Analysis:

1. Government Doctors per Hospital
2. State per capita GDP
3. Expenditure
4. Rural Primary Healthcare Centers
5. Number of Government Hospitals
6. Birth Rate
7. Poverty Rate
8. Literacy Rate

**Table I: This is the result of Cross-Correlation Analysis done on eight independent variables in 2011.**

| | Doctors per Hospital | State per capita GDP | State Expenditure | Rural PHC | No of Hospitals | Literacy Rate | Poverty Rate | Birth Rate |
|---|---|---|---|---|---|---|---|---|
| Doctorsper Hospital | 1 | | | | | | | |
| State per capita GDP | -0.04945 | 1 | | | | | | |
| State Expenditure | 0.06778 | 0.65833 | 1 | | | | | |
| Rural PHC[8] | -0.16300 | -0.17311 | 0.41031 | 1 | | | | |
| No of Hospitals | -0.44271 | -0.16348 | -0.42260 | 0.66282 | 1 | | | |
| Literacy Rate | 0.11925 | 0.21605 | 0.45821 | -0.48114 | -0.31396 | 1 | | |
| Poverty Rate | -0.38378 | 0.30114 | -0.10633 | -0.02614 | 0.14002 | -0.34944 | 1 | |
| Birth Rate | 0.00376 | -0.04431 | -0.34072 | 0.45371 | 0.20234 | -0.72270 | 0.42369 | 1 |

### 2.4 Results of Regression Analysis

Then, Linear Multivariable Regression Analysis was carried out for the Normalised Disease Case Rate on these eight independent Variables in 2011.

**Table II: This analysis represents the Normalised Case Rate of 4 Common Infectious Diseases in India and its dependence on eight independent variables and has an $R^2$ value of 0.674.**

| | Intercept | Doctors per Hospital | State per capita GDP | State Expenditure | Rural PHC | No of Hospitals | Literacy Rate | Poverty Rate | Birth Rate |
|---|---|---|---|---|---|---|---|---|---|
| Coefficients | -557.726 | -0.14594 | -0.31147 | 75.4750 | -0.04428 | 0.05688 | 2.43767 | -2.15777 | 8.40330 |

### 2.5 Predicted Normalised Case Rate for 4 Common Infectious Diseases

This 2011 Linear Regression Analysis was then used to predict the Normalised Case Rate in 2008.

[7] This was done using R
[8] Primary Healthcare Centers

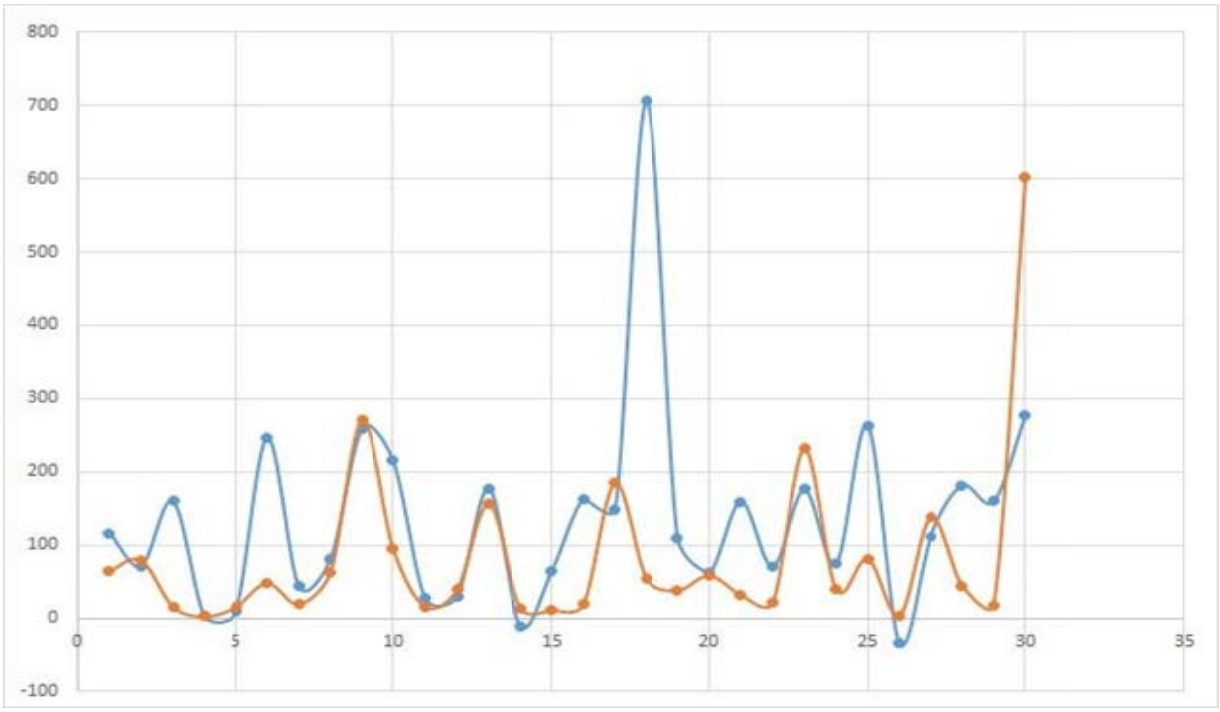


**Figure I: This is a graph of the actual Normalised Case Rate along with the Predicted Normalised Case Rate. Here, orange represents the Predicted Normalised Case Rate and blue represents the Actual Normalised Case Rate in 2008.**

### 2.6 Predicted Normalised Case Rate for Malaria

Malaria is the most common infectious disease in India. Thus, Linear Multivariable Regression Analysis of the Normalised Case Rate of Malaria was carried out on these eight independent Variables in 2011. The results of this analysis are as follows:

**Table III This analysis represents the Normalised Case Rate of Malaria and its dependence on eight independent variables and has an $R^2$ value of 0.626.**

| | Intercept | Doctors per Hospital | State per capita GDP | State Expenditure | Rural PHC | No of Hospitals | Literacy Rate | Poverty Rate | Birth Rate |
|---|---|---|---|---|---|---|---|---|---|
| Coefficients | -1.77129 | 0.058671 | -0.00267 | 0.034759 | -0.00308 | 0.003971 | -0.03255 | 0.069966 | 0.272654 |

This 2011 Linear Regression Analysis was then used to predict the Normalised Case Rate of Malaria in 2008.

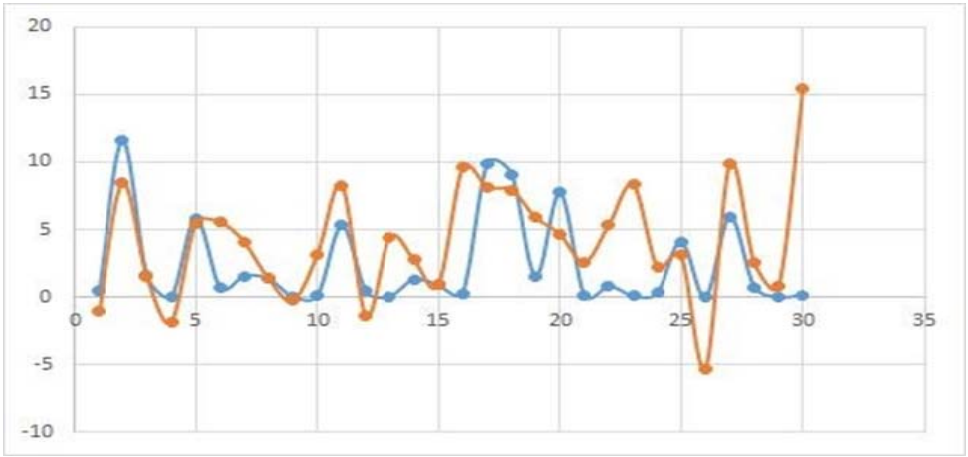


**Figure II: This is a graph of the actual Normalised Case Rate of Malaria as well as the Predicted Normalised Case Rate of Malaria. Here, orange represents the Predicted Normalised Case Rate and blue represents the Actual Normalised Case Rate in 2008.**

The accurate predictions of the Normalised Case Rate of Infectious Diseases as well as of the Normalised Case Rate of Malaria of 2008 using the Regression Model for 2011 verifies the Regression Model developed in this study. This study highlights the high dependence of Normalised Case Rate of Infectious Diseases on the State Expenditure on Healthcare, Birth Rate, Poverty Rate and Literacy Rate.

## 3. Results

Some outcomes of this analysis, verified by Mr. Chandrakanth Mishra, Director Institutional business, Religare Health Insurance, are as follows:

### 3.1 Direct Conclusions

The Normalised Case Rate of Infectious Diseases is dependent on State Expenditure towards Healthcare by a significant amount. It is also strongly related to the Birth Rate, Literacy Rate and Poverty Rate of a state. However, it is almost independent of the number of Rural Primary Healthcare Centers and the number of Government Hospitals in a state.

### 3.2 Reasoning for Conclusions

The Normalised Case Rate of Infectious Diseases in different states is dependent mainly on the condition of living of the population, which entails hygiene and sanitary factors. It is also dependent on the access to healthcare of the people in the state. This is validated by the fact that urban towns, where people have better access to healthcare, have a higher incidence of infectious diseases which are caused due to the pollution and poor living conditions of people in cities.

The quality of life of the people in a developed state is measured using two crucial metrics: Literacy rate and Poverty Rate. The Literacy Rate is higher in most high-income states. People are more aware of ways to combat infectious diseases. Thus, the Normalised Case Rate is lower in states with high Literacy Rate. However, some states with a high Literacy Rate may still have a high Normalized Case Rate of Infectious Diseases. This is the case in states like Kerala, where there is insufficient access to healthcare.

A large amount of attention is given to the Infant Mortality in states. State governments are highly motivated to reduce the Infant Mortality Rate, which has led to states spending more of their budget. There are several government schemes which are focused solely to do this. Examples of such schemes are *Janani Suraksha Yojana (JSY) and Janani Shishu Suraksha Karyakaram (JSSK) which entitle all pregnant women (PW) delivering in public health institutions to free ante-natal check-ups, delivery including Caesarean section, postnatal care and treatment of sick infants till one year of age and promote Institutional deliveries through cash incentive. The India Newborn Action Plan (INAP) was launched in 2014 to make concerted efforts towards the attainment of the goals of "Single Digit Neonatal Mortality Rate" and "Single Digit Stillbirth Rate," by 2030.*[9] Such a large number of schemes are due to the Infant Mortality Rate being one of the basic parameters on which states are judged. All of this would lead to underdeveloped states would have a higher Normalised Case Rate of Infectious Diseases.

When the per capita GDP, i.e. income in a state is high, medical facilities in the state tend to be superior. This is because the state has more capital to spend on healthcare and other auxiliary expenses resulting in a better quality of life of people living in the state. People also have better access to healthcare, and thus, more cases of infectious diseases are diagnosed and reported in high-income states.

However, even in developed states in India, there is insufficient spending on healthcare infrastructure, awareness building and health education. In first-world countries, spending on healthcare is around 5%, in India it is 2%. Thus, education and healthcare in India do not get the funding required. Some states having a high state GDP still have a high Normalised Case Rate of Infectious Diseases. For example, Gujarat has a very high case rate of gastrointestinal infections and swine flu. This is due to their low nutritional index, especially in infants.

In India, even in developed states, the state medical infrastructure is still inadequate. The number of hospitals and doctors per thousand is still far less than the number in foreign countries. Once the infrastructure is adequate for the population size to have proper access to healthcare and medical facilities, the Normalised Case Rate of Infectious Diseases should fall dramatically.

## References

[1] Diseases: Cases and Deaths - Directorate General of State Health Services
[2] State Expenditure on Healthcare - Budget documents of the state governments, CAG for 2015-16 in respect of Jammu & Kashmir
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[4] State per capita GDP - Ministry of Statistics and Programme Implementation
[5] Estimated birth rates, death rates and Infant Mortality Rate - data.gov.in

[9] Press Information Bureau, Government of India

[6] The Population of States - Office of the Registrar General of India, Ministry of Home Affairs
[7] Number of Government Hospitals, Allopathic Doctors and Hospital Beds - Directorate General of State Health Services
[8] Rural Health Infrastructure - Ministry of Health & Family Welfare
[9] Literacy Rate - NITI Aayog, (National Institution for Transforming India)
[10] Poverty Rate - Reserve Bank of India, Census September 16, 2015
[11] World Malaria Report, 2013
[12] Dengue In India - World Health Organisation, 2018
[13] Press Information Bureau, Government of India