

# International Journal of Statistics and Applied Mathematics

ISSN: 2456-1452  
Maths 2024; 9(5): 121-128  
© 2024 Stats & Maths  
<https://www.mathsjournal.com>  
Received: 17-08-2024  
Accepted: 20-09-2024

**Sumbul SK**  
Department of Statistics,  
University of Allahabad,  
Prayagraj, Uttar Pradesh, India

**M Naresh**  
Department of Statistics, Sri  
Venkateswara University,  
Tirupati, Andhra Pradesh, India

**G Madhu Sudan**  
Assistant Professor, Department  
of Statistics, University of  
Allahabad, Prayagraj, Uttar  
Pradesh, India

**Corresponding Author:**  
**Sumbul SK**  
Department of Statistics,  
University of Allahabad,  
Prayagraj, Uttar Pradesh, India

## Factors affecting under-five child mortality rate in India

**Sumbul SK, M Naresh and G Madhu Sudan**

**DOI:** <https://doi.org/10.22271/math.2024.v9.i5b.1824>

### Abstract

Modern science and technology have made enormous strides in medicine and healthcare to reduce the danger of early childhood mortality. Even so, many nations fall well short of the basic Sustainable Development Goals (SDGs) objectives, which are meant to lower the death rate of children under five. Under five child mortality rates can be one of the indicators of describing the development of the country; the lesser the value of mortality, the better the country for a child in terms of survival and may be treated as a measure of health care facilities. Over the past few decades, child mortality in India has significantly decreased, contributing to the country's achievement of the fourth Millennium Development Goal (MDG 4). However, the death rate for children under five is still somewhat high, and significant work will be required to meet the SDG target and lower the present rate of under-five deaths. Therefore, it is crucial to investigate the factors that contribute to under-5 fatalities at this point in order to lessen the likelihood that a kid will survive. This study's primary goal is to investigate and pinpoint the variables linked to child mortality rate in India under the age of five.

**Keywords:** Demography, regression analysis, exploratory data analysis and python

### Introduction

Information and awareness of child mortality are important factors for determining the demographic pattern of the population and it's also indicating one's country's socioeconomic growth and development. It indexed the quality of life in one's country. As we know children are important assets of any nation. One nation's future and development are dependent on the healthy development and growth of its child population. Every child in this world has a right to a safe birth, proper pre-and post-natal care, survival, mandatory education, vital food, and healthcare that all are necessary for a healthy life. Since early ages are more exposed to fatal death causes. The healthy development of children is crucial to the future well-being of any civilization. Because they are still developing, children are especially vulnerable – more so than adults – to poor living conditions such as poverty, inadequate health care, nutrition, safe water, housing, and environmental pollution. The effects of disease, malnutrition, and poverty threaten the future of children and therefore the future of the societies in which they live. The costs to society of failing its children are huge. It is experienced the children's earliest experiences significantly influence their future development. The information of survival and healthy development of children will help taking appropriate measures and policy decisions in right directions.

According to the United Nations World Population prospectus (2022) now there are 1.9 billion children in the world, but they are but 27% of the world population and it is projected that 136 million babies will be born worldwide in 2050. In 2050, the estimate will be still 1.9 billion but comprising 20% population. Children belong to a vulnerable section of the population. Sustaining and encouraging a healthy state of children and preserving sustainable survival is very important. Child mortality is a key indicator of a child 's state of well-being and sustenance but also for the execution of Millennium Development, Goal 4 aim resulted in a 2/3<sup>rd</sup> reduction in the under-five mortality rate between 1990 and 2015. With the renewed focus on child survival, tracking of progress in the reduction of child mortality is increasingly

important that's why sustainable development goals are set up. As we all have seen in the recent pandemic situations how the threatening drop in mortality could be, it was well cognized that keeping up with sustained growth and protecting even more lives would need the utilization of proper sources and adequate care. This understanding of the survival of children for survival of mankind and improving the quality of their lives led to the inclusion of child survival goals in several global visions including the United Nations Global Strategy for Women's Children's and Adolescents' Health (2016-2030) and the Sustainable Development Goals (SDGs). SDG Target Goal 3.2 calls for ending preventable deaths of new-borns and children under age 5, with all countries aiming to have a neonatal mortality rate of 12 or fewer deaths per 1,000 live births and an under-five mortality rate of 25 or fewer deaths per 1,000 live births by 2030. With a vision to reduce CHILD mortality and reductions in preventable causes of death. Currently, UN IGME estimates child mortality which is critical to the monitoring of progress toward the SDG goal. In recent last 30 years have observed striking reductions in child mortality under-five mortality have dropped by almost 60 per cent since 1990 to 38 deaths per 1,000 live births in 2019— still, the global burden of child deaths remains immense according to UN IGME Report on levels and trends in child mortality (2020). It also states that in 2019 alone, 7.4 (7.2, 7.9) million children, adolescents and youth died mostly of preventable or treatable causes. In 2019, globally, 70 per cent of deaths among children global under-five mortality rate fell to 38 (36, 41) deaths per 1,000 live births in 2019 from 93 (92, 95) in 1990 and 76 (75, 77) in 2000 – a 59 (56, 61) per cent and 50 (46, 52) per cent decline, respectively. Occurred among children under 5 years of age, accounting for 5.2 (5.0, 5.6) million deaths. Among under-five deaths, 2.4 million (47 per cent) occurred in the first month of life, 1.5 million (28 per cent) at age 1–11 months, and 1.3 million (25 per cent) at age 1–4 years. (UN IGME) If the child survival SDG targets are to be fulfilled on time, resources and policy must be geared toward not only sustaining current rates of decline but also accelerating progress, which would save millions of lives. Demography and Health Surveys (DHS) are nationally-representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health, and nutrition.

According to UNICEF in 2021, 5.0 million children under 5 years of age died.

The global under-five mortality rate declined by 59 per cent, from 93 deaths per 1,000 live births in 1990 to 38 in 2021. In 2021 alone, roughly 13,800 under-five deaths occurred every day.

**DHS regularly collects data on infant and child mortality and child health:** Several standard measures and indicators of childhood mortality are calculated using DHS survey data:

- **Neonatal mortality:** The chances of dying within the first month of life
- **Infant mortality:** The chances of dying before the first birthday
- **Post neonatal mortality:** The difference between infant and neonatal mortality
- **Under-five mortality:** The chances of dying before the fifth birthday
- **Child mortality:** The chances of dying between the 1-5 years.

Under-5 Child mortality rate is a leading indicator of the level of child health and overall development in countries. It is an important index for estimating the health status, availability of proper medical infrastructure, and in the eradication of preventable diseases thus saving lives., The under-five mortality rate refers to the probability a new born would die before reaching exactly 5 years of age, expressed per 1,000 live births. According to UNICEF in 2021, 5.0 million children under 5 years of age died. Globally, infectious diseases, including pneumonia, diarrhoea, and malaria, remain a leading cause of under-five deaths and preterm birth and intrapartum-related complications. The global under-five mortality rate declined by 59 percent, from 93 deaths per 1,000 live births in 1990 to 38 in 2021. Despite this considerable progress, improving child survival remains a matter of urgent concern. In 2021 alone, roughly 13,800 under-five deaths occurred every day, an intolerably high number of largely preventable child deaths.

According to the UNIGME Report, India a developing country with most of the world's population experienced half of the most under-five deaths in third with Nigeria although there is a decline in overall under-five child mortality rates from previous times but still among the top 5 counties with most no. of deaths. According to NFHS -5 Survey report, the five previous years before the survey 42 deaths are reported per 1000 live births. These estimates will be helpful to reduce under-five deaths risk and to implement several measures to improve the quality of life in India.

### Objective

The objective is to study and analyse the determinants which factors are affecting under-five child mortality in India by using Multiple Linear Regression and conducting Exploratory Data Analysis (EDA) of under-five mortality rates using NFHS-5 Survey Data.

### Data Sources

National Family Health Survey (NFHS): National Family Health Survey 2019-21 (NFHS-5), the fifth in the NFHS series, provides information on population, health, and nutrition for India, each state/union territory (UT). The data used for compiling this report has been downloaded from Harvard Data verse:

<https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/42WNZF>

### Materials and Methods

#### Variable Description

- **Dependent Variable:** U5MR= Under-five mortality rate
- **Independent Variables:** (Listed below numbered 1-19)
  1. **Antenatal\_Care:** Mothers who had at least four antenatal care visits (%).
  2. **Fully\_Vaccinated:** Children 12-23 months fully vaccinated based on information from either vaccination card or mother's recall (%).
  3. **Adult Diet:** Children under 5 who received adequate diet
  4. **Young\_Preg:** Young age pregnancy and motherhood.
  5. **F\_Education:** Level of schooling of more than 10 years for females (household %)
  6. **MCP:** Registered pregnancies for which the mother received a Mother and Child Protection (MCP) card (%)
  7. **Iod\_Salt:** Households using iodized salt (%).
  8. **Postnatal\_Care:** Children who received postnatal care from a doctor/nurse/LHV/ANM/midwife/other health person within 2 days of delivery (%)

9. **SCP:** Births attended by skilled health person (%)
10. **BCG:** Children the age 12-23 months who have received BCG (%)
11. **POLIO:** Children the age 12-23 months who have received 3 doses of polio vaccine13 (%)
12. **DPT:** Children the age 12-23 months who have received 3 doses of Penta or DPT vaccine (%)
13. **M1:** Children aged 12-23 months who have received the first dose of measles-containing vaccine (MCV) (%)
14. **M2:** Children age 24-35 months who have received a second dose of measles-containing vaccine (MCV) (%)
15. **HP:** Children age 12-23 months who have received 3 doses of penta or hepatitis B vaccine (%)
16. **R.V:** Children age 12-23 months who have received doses of rotavirus vaccine14 (%)
17. **VIT.A=** Children age 9-59 months who received a vitamin A dose in the last 6 months (%)
18. **WOM.ANAEMIC=** women age 15-49 years who are anaemic
19. **Child.UNDER Weight=** CU5 years who are underweight (weight-for- age)

**Multiple linear regression:** Multiple linear regression model is given by

$$y_i = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_kx_k + \varepsilon_i; \forall i = 1, 2, \dots, k$$

is used to estimate the relationship between two or more independent variables ( $x_1, x_2, x_3, \dots, x_k$ ), one dependent variable ( $y_i$ ) and error variable ( $\varepsilon_i$ ). The following are the assumptions of multiple linear regression model.

1. **Linearity:** Linear relationship between the dependent (Y) and independent variables (X).
2. **Normality:** The residuals are normally distributed.
3. **No multicollinearity:** There is no high relationships among all independent variables.
4. **No Heteroscedasticity:** The error variance ( $\sigma^2$ ) is homogeneous (same variance).

**Exploratory Data Analysis (EDA)**

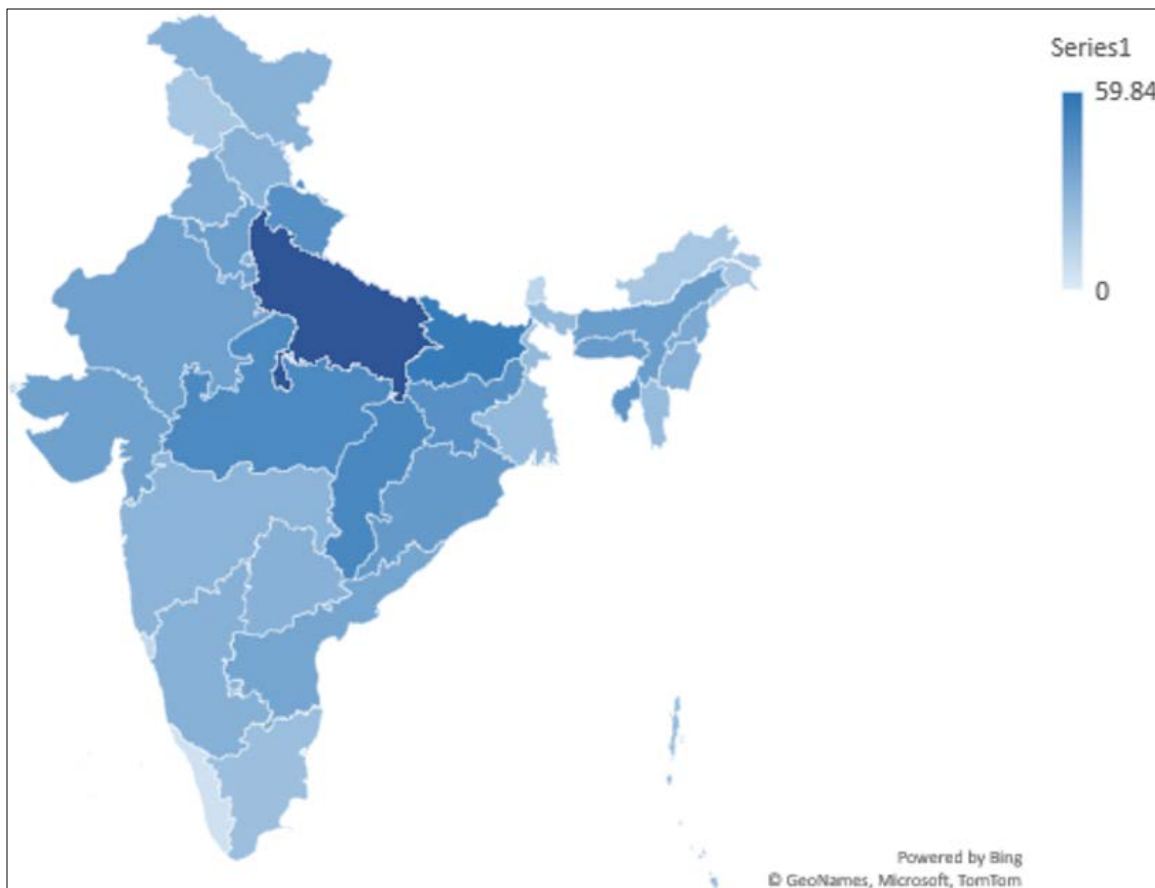
Which is an approach to analysing data sets to summarize their main characteristics, often with visual methods. Originally developed by American mathematician John Tukey in the 1970's, EDA techniques continue to be a widely used method in the data discovery process today. The main goals of EDA are to:

- Summarize the main characteristics of the data
- Identify patterns and trends in the data
- Check the assumptions of the data
- Identify outliers and anomalies
- Formulate hypotheses for further analysis

In R programming and Python, there are many libraries that can be used to perform EDA, such as ggplot2, matplotlib, seaborn, and pandas. These libraries provide a wide range of visualization and data manipulation functions that can be used to perform EDA. In conclusion, EDA is an approach to analysing data sets to summarize their main characteristics, identify patterns and trends, and formulate hypotheses for further analysis.

**Empirical Investigation**

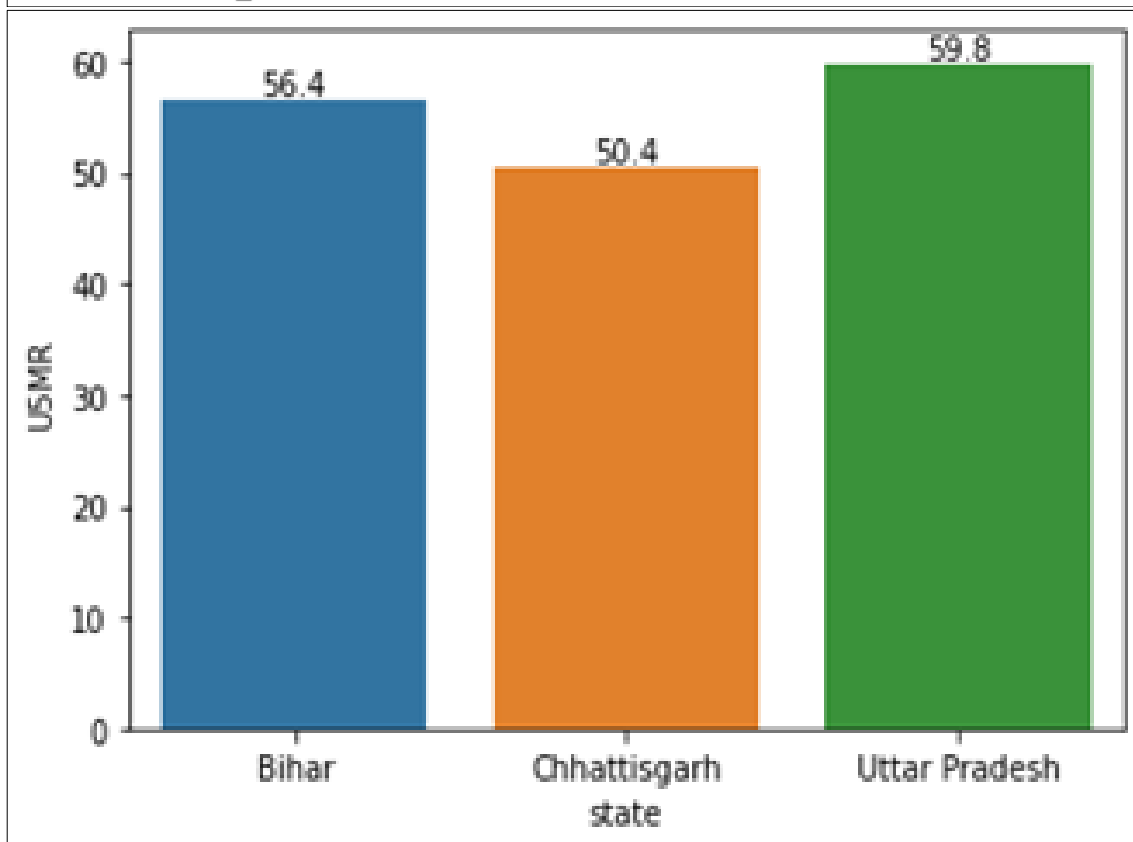
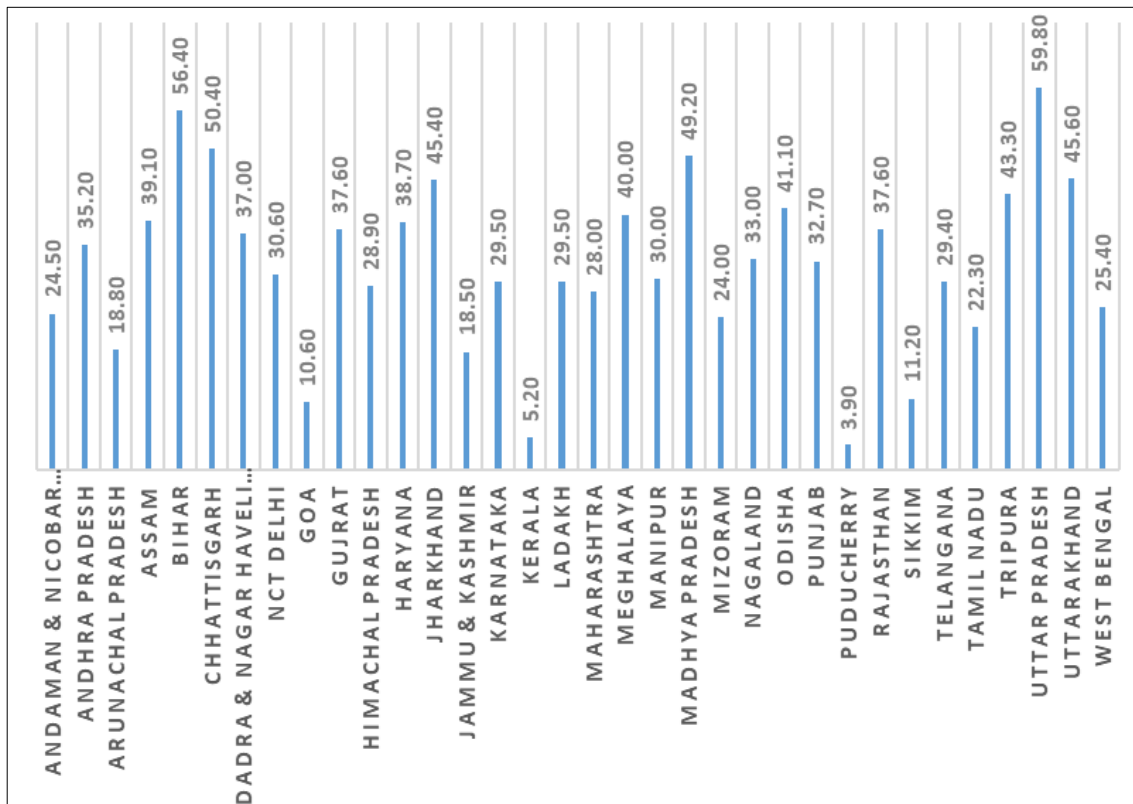
On the basis of correlation Map of India is categorised in colour various components.



**Fig 1:** Under –five mortality rate in India

The dark region in the map of India represents the states of Uttar Pradesh with the highest rate of under-five mortality which is 59.8, followed by Bihar at 56.4 and Chhattisgarh 50.4. The lightest shade in the map was observed in the lowest under-five mortality rate Pondicherry which has 3.9

and Kerala with a value 5.2 which has the least under-five child mortality 5.2. The moderate-colored geographical regions depict the states with moderate rates of under-five child mortality.



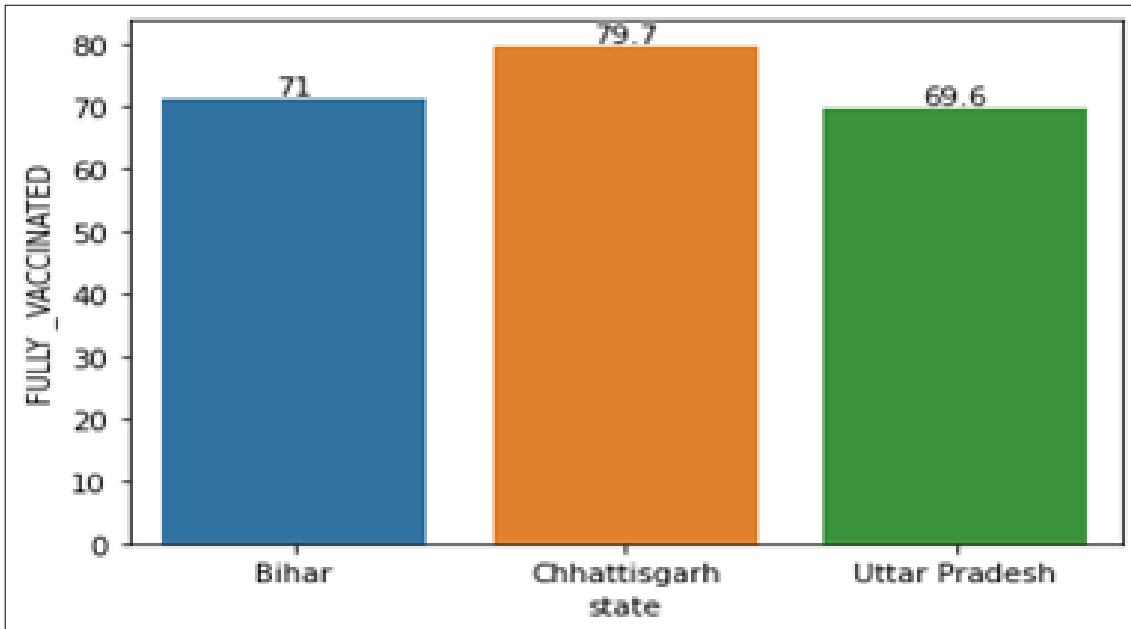


Fig 2: State wise U5MR

The above listed chart represents the states which have high under five mortality rate although the vaccination rate is highest but still rate is above 50.

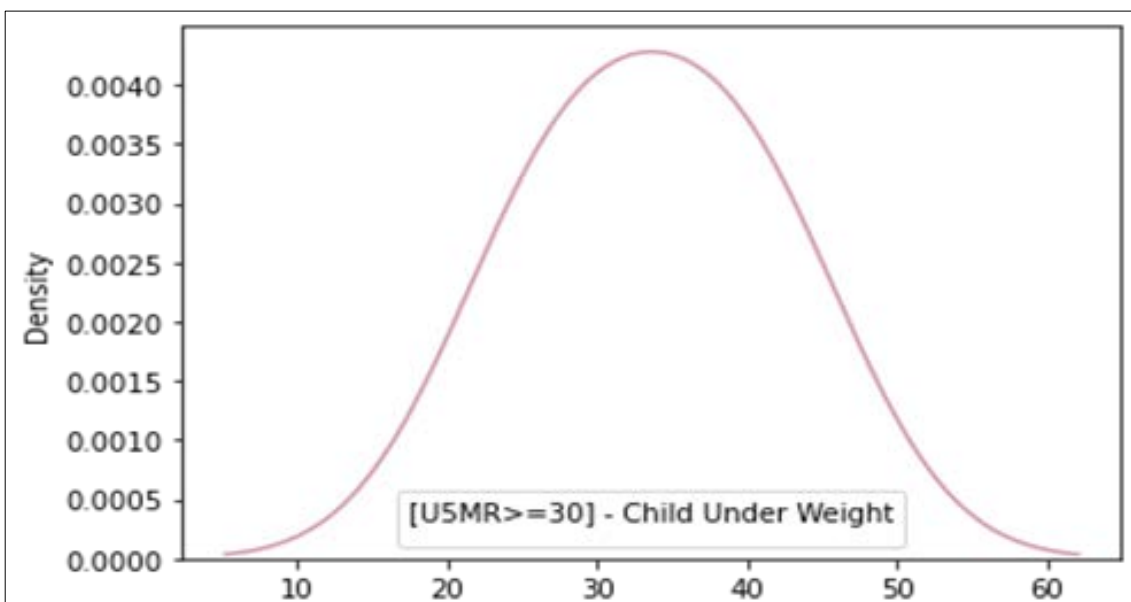
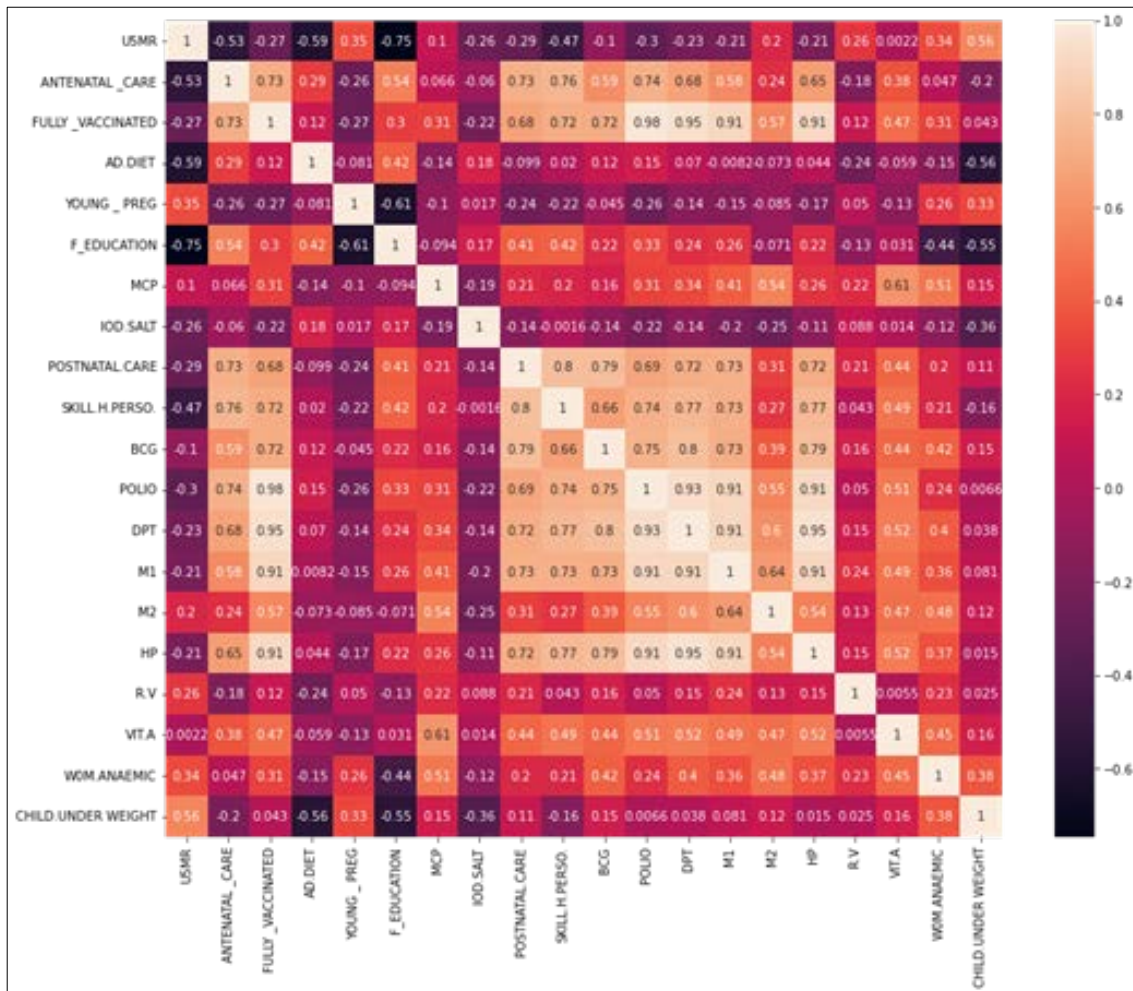


Fig 3: Child under weight

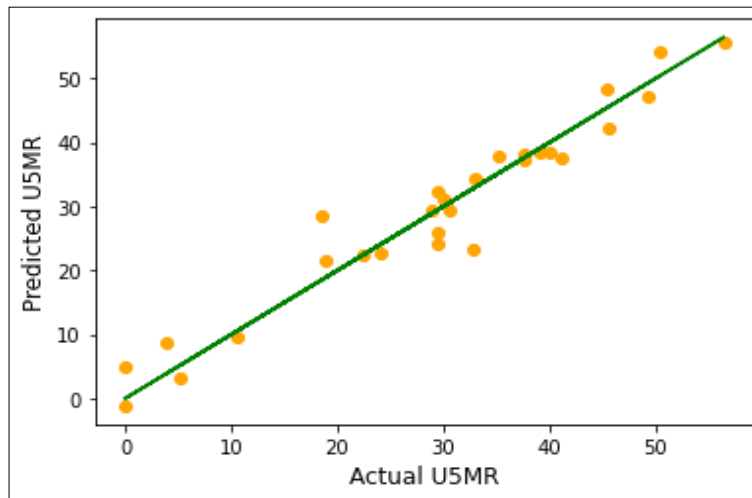
The above density curve shows that there is a high chance of U5MR due to Under Weight Child.



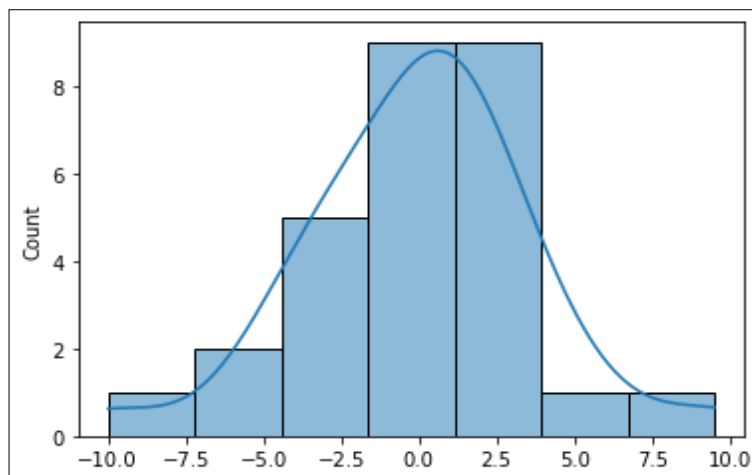
The above is the heat map which is representing the correlation matrix between dependent and independent Variables.

	coef	std err	t	P> t	[0.025	0.975]
<b>const</b>	29.1974	1.566	18.640	0.000	25.585	32.809
<b>ANTENATAL_CARE</b>	10.3291	5.569	1.855	0.101	-2.512	23.171
<b>FULLY_VACCINATED</b>	3.8292	17.497	0.219	0.832	-36.520	44.178
<b>AD.DIET</b>	-9.4000	3.035	-3.097	0.015	-16.398	-2.402
<b>YOUNG_PREG</b>	-4.7456	5.487	-0.865	0.412	-17.399	7.908
<b>F.EDUCATION</b>	-12.3760	4.187	-2.956	0.018	-22.032	-2.721
<b>MCP</b>	-3.8194	3.445	-1.109	0.300	-11.764	4.126
<b>IOD.SALT</b>	-4.0844	2.113	-1.933	0.089	-8.957	0.788
<b>POSTNATAL.CARE</b>	-20.9721	7.189	-2.917	0.019	-37.551	-4.394
<b>SKILL.H.PERSO.</b>	-10.1616	4.879	-2.083	0.071	-21.412	1.088
<b>BCG</b>	18.7173	5.397	3.468	0.008	6.273	31.162
<b>POLIO</b>	-18.8031	15.246	-1.233	0.252	-53.959	16.353
<b>DPT</b>	-6.5364	12.469	-0.524	0.614	-35.289	22.217
<b>M1</b>	27.6120	13.587	2.032	0.077	-3.719	58.943
<b>M2</b>	-2.5648	3.715	-0.690	0.509	-11.131	6.002
<b>HP</b>	-3.7865	6.694	-0.566	0.587	-19.224	11.651
<b>R.V</b>	2.0363	2.719	0.749	0.475	-4.234	8.306
<b>VIT.A</b>	7.0993	3.407	2.084	0.071	-0.758	14.957
<b>WOM.ANAEMIC</b>	-4.8571	3.689	-1.317	0.224	-13.363	3.649
<b>CHILD.UNDER WEIGHT</b>	-5.2233	4.661	-1.121	0.295	-15.971	5.524

<b>Omnibus:</b>	3.358	<b>Durbin-Watson:</b>	2.297
<b>Prob(Omnibus):</b>	0.187	<b>Jarque-Bera (JB):</b>	2.160
<b>Skew:</b>	-0.144	<b>Prob(JB):</b>	0.340
<b>Kurtosis:</b>	4.330	<b>Cond. No.</b>	55.4



**Predicted Vs Actual U5MR**



**Density Plot for Residual**

- **Breusch Pagan Test:** A Breusch-Pagan test uses the following null and alternative hypotheses:
- **The null hypothesis (H<sub>0</sub>):** Homoscedasticity is present.
- **The alternative hypothesis: (H<sub>1</sub>):** Homoscedasticity is not present (i.e. heteroscedasticity exists)

<b>Lagrange multiplier statistic</b>	18.78151954700229
p-value	0.470930310565219
F-Statistic	0.918548910503886
p-value	0.574773152786839

<b>OLS – Regression - Table</b>			
Dep. Variable	U5MR	R-squared	0.941
Model	OLS	Adj. R-squared	0.801
Method	Least Squares	F-statistic	6.703
Probability	0.00485		
Log-Likelihood	-75.83800		
No. Observations	28	AIC	191.7
Dof Residual	8	BIC	218.3
Dof Model	19		

**Discussion and Conclusion**

1. U5MR shows the linear relationship with the independent variables.
2. R- Squared is Equal to 94.1% it means that variability on the dependent variable due to the independent variable is high.
3. Adjusted R – Square or Accuracy is 80.1%.
4. Density plot of the residual clearly shows that the residual is normally distributed.
5. The Durbin-Watson statistic is a test for autocorrelation in a regression model's output. The DW statistic ranges from zero to four, with a value of near 2.0 indicating zero autocorrelation.
6. The Lagrange multiplier statistic for the test comes out to be equal to 18.781 and the corresponding p-value comes out to be equal to 0.471. Since the p-value is greater than 0.05, we couldn't reject the null hypothesis. Standardisation of independent variables removed Multi-collinearity.

## Conclusion

In conclusion, child mortality remains a significant public health challenge in India. Despite improvements in access to health care and nutrition, the country still experiences high rates of child mortality due to a combination of factors including poverty, inadequate sanitation, poor maternal health, and a shortage of trained health care workers. Addressing these underlying issues will be crucial in reducing child mortality and improving the health and well-being of children in India. Moreover, implementing effective health education and prevention programs, strengthening the health care system, and addressing the social determinants of health can help to mitigate the impact of child mortality in India. In order to achieve the goal of reducing child mortality, will require a concerted effort from both the government and society as a whole.

## References

- Ahmad OB, Lopez AD, Inoue M. The decline in child mortality: A reappraisal. *Bulletin of the World Health Organization*. 2000;78(10):1175-1191. PMID: 11100613; PMCID: PMC2560617.
- Dutta M, Kapur PN. Trends and differentials in infant mortality in India: 1950-1978. In: *Mortality in South and East Asia: A Review of Changing Trends and Patterns, 1950-1975*. Report and selected papers presented at the Joint WHO/ESCAP meeting held in Manila: 1-5 Dec. 1980. WHO and UNESCAP; c1982. p. 215-232.
- Figa IT. Infant and child mortality in the rural areas of the developing world: A review of recent trends and policy implications. *Genus*. 1984;40(1-2):131-153.
- Hobcraft JN, McDonald JW, Rutstein SO. Socio-economic factors in infant and child mortality: A cross-national comparison. *Population Studies*. 1984;38:193-223.
- Madhu Sudan G. The Role of Statistical Packages in Academic and Industry. *An International Multidisciplinary Research Journal (IJMR)*. 2017;7(10):405-425. DOI: 10.5958/2249-7137.2017.00097.0.
- McGuire JW. Basic health care provision and under-5 mortality: A cross-national study of developing countries. *World Development*. 2006;34:405-425.
- Mosley WH, Chen L. An analytical framework for the study of child survival in developing countries. In: Mosley WH, Chen L, eds. *Child Survival: Strategies for Research*. *Population and Development Review*. 1984;10(suppl.):25-45.
- Ruzicka LT, Hansluwka H. A review of evidence on levels, trends, and differentials since the 1950s. In: *Mortality in South and East Asia, A Review of Changing Trends and Patterns, 1950-75*. Report and selected papers presented at the joint WHO/ESCAP meeting held in Manila: 1-5 Dec. 1980. WHO and UNESCAP; c1982. p. 83-156.
- United Nations Department of Economic and Social Affairs, Population Division. *World Population Prospects Summary of Results; c2022*. UN DESA/POP/2022/TR/NO. 3; 2022.
- United Nations Inter-Agency Group for Child Mortality Estimation (UN IGME). *Levels & Trends in Child Mortality: Report 2020*, Estimates developed by the United Nations Inter-Agency Group for Child Mortality Estimation. New York: United Nations Children's Fund; c2020.
- United Nations Inter-Agency Group for Child Mortality Estimation (UN IGME). *Levels & Trends in Child Mortality: Report 2018*, Estimates developed by the United Nations Inter-Agency Group for Child Mortality Estimation. New York: United Nations Children's Fund; c2018.
- United Nations. *Socio-economic differentials in child mortality in developing countries*. New York: United Nations; 1985. *Child mortality in developing countries: Socio-economic differentials, trends, and implications*. New York: United Nations; 1991. *Too young to die: Genes or gender?* New York: United Nations; c1998.
- Vishnu Priya, Madhu Sudan G, *et al.* Specification and Estimation of a Biometric Model by Using Logistic Regression for Measuring Child Mortality. In: *Learning and Analytics in Intelligent Systems*. Springer. 2019;15:439-446.