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Predicting infant mortality in India using time series models

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Abstract

Predicting infant mortality rate is an important aspect of study to prepare society and government for better or worst in future. Many Programs might approach to fulfill the desired target in given time. In study an approach of time series models had used for prediction of infant mortality in India and some of its states. States had been selected by using the target stated in revised population policy 2017. In the study we found 13 states of India which does not have twenty eight per thousand infant mortality Rate in 2016 SRS data. We made our prediction using time series model named as Autoregressive Integrated Moving Average Method. This Chapter also compares these results to previous attempt to predict IMR Using ARIMA models.

Keywords: Predicting infant mortality, India using time series models

1. Introduction

The infant mortality is judged as a comprehensive indicator of socio-economic development. Policy-making bodies like World Health Organization (WHO), United Nations (UN) have been using it as an important indicator to measure the socio-economic development of a country. It is often used as an indicator to understand the equity of distribution of resources and investment in health and social services (WHO, 2001) [12]. The UN currently uses IMR as a measure of social well-being and considers the trends of IMR as one of the indicators to achieve the Millennium Development Goals (MDG). Its target is to two third reduction in infant mortality rate (IMR) from 1990 to 2015 (United Nations, 2000). Thus study of under-five mortality trends and the possible explanations for such trends are of prime importance to understand socio-economic progress and investment in public health (De, 2011) visualized in sustainable development goals too.

The International Conference on Primary health care held in Alma Ata in 1978 was the first global forum to consider how child and infant mortality could be reduced by the systematic development of primary health care system (WHO, 1978) [11]. Ahmad *et al.* (2000) [6] suggested that rapid rate of decline observed earlier was not sustainable given the slow rate of economic development and infusion of a very narrowly defined set of sophisticated technology-driven public health inventions.

India has made steady progress in reducing deaths in children younger than 5 years, with total deaths declining from 2.5 million in 2001 to 1.5 million in 2012 (UN, 2012) [10]. Neonatal and 1-59 month mortality vary substantially between subregions of India as a result of the underlying differences in social and economic status, child nutrition status, health services, work culture, gender bias, and other factors that affect child mortality. The National Rural Health Mission recommends district-based planning for maternal child health programs and, indeed, for other disease-specific initiatives (Bhan, 2013) [4]. Benicio *et al.* (1985) [5] studied the declining trend of the infant mortality rate in Sao-Paulo during the 1980 in relation to the improvement of social conditions, especially the increased numbers of households with mains water, the schooling levels of parents, and the expanded reach of health services as reflected in vaccination coverage and hospital attendance. Concurrent with the improving profile of infant mortality in the city, the rise in mortality associated with perinatal events and nutritional deficiencies in the poorest areas reflected increasing social inequalities (Monteiro, *et al.* 1995) [1].

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Proposing and planning the programs related to infant mortality are based on the present conditions to improve future. That initiates the curiosity that what will be future if no new programs or plans are included in population at present. Which turns to idea of future prediction. General future predictions are made by the base of some past data. Sample registration system data is being used for past study. To predicting the infant Mortality various methods are available. In recent times the time series models are considered quite useful in predicting the demographic phenomenon. These methods are Simple moving average (SMA), Exponential Smoothing System (SES), Autoregressive integrated moving Average method (ARIMA), Neral Network (NN) and Crosten. Tripathi *et al.* (2018) ^[9] proposed the Baysian Approach of ARIMA model in Indian Context to predict the total fertility rate. De *et al.* (2016) ^[8] Suggested to use the ARIMA model to predict Child mortality in some states of India for the duration of 2015-2030. He also suggested that if a predicted values in future vary from original values that might effect whole other predicted values. This chapter is an attempt to predict infant mortality rate in India and some of its states up to sometime points in future Using ARIMA Model using De *et al.* (2016) ^[8] results with its corresponding diagnostics and also being compared to results of those states whose infant mortality had predicted by De *et al.* (2016) ^[8] because observed infant mortality of 2014, 2015 and 2016 are different from predicted values in De *et al.* (2016) ^[8]. Now for better studies we move to data and methodology section.

2. Data and Methodology

2.1 States

National population policy (2017) set up the target of IMR of twenty eight per thousand by 2019 in All India. So only those states are considered who have not the IMR twenty eight per thousand by 2016. These states are:

1. Andhra Pradesh (34)
2. Assam (44)
3. Bihar (38)
4. Chhatisgarh (39)
5. Gujrat (30)
6. Haryana (33)
7. Jharkhand (29)
8. Madhya Pradesh (47)
9. Meghalaya (39)
10. Odisha (44)
11. Rajasthan (41)
12. Uttar Pradesh (43)
13. Uttarakhand (38)

2.2 Arima Model Assumptions

The main Assumption is that ARIMA models is of stationarity of process over time or a process whose Unconditional joint probability distribution does not change when shifted in time if not it will transformed into it before applying ARIMA.(Box and Jenkins(1970)).

2.3 Arima Model

Given a time series of data X_t where t is an integer index and the X_t are real numbers, an ARIMA (p, q) model is given by

$$X_t - \alpha_1 X_{t-1} - \dots - \alpha_p X_{t-p} = \varepsilon_t + \theta_1 \varepsilon_{t-1} + \dots + \theta_q \varepsilon_{t-q} \quad (1)$$

or equivalently by

$$(1 - \sum_{i=1}^p \alpha_i L^i) X_t = (1 + \sum_{i=1}^q \theta_i L^i) \varepsilon_t \quad (2)$$

Where L is the lag operator, the α_i are the parameters of the autoregressive part of the model, the θ_i are the parameters of the moving average part and the ε_t are error terms.

Standard Form of ARIMA Consists with three Values (p,d,q) where p is autoregressive term, d is the difference, and q is moving average estimate, to evaluate value of (p,d,q) different graphs have been used over time. In this chapter the values of IMR have been predicted for above states and India to obtain that when the target of 28/1000 achieved by India and these states and How many years the states are behind or forward to achieve the target than India. The estimated values of p,d,q are considered as the values of De *et al.* (2016) ^[8]. Data of SRS from 1980-2016 have been taken except for 3 states as Chhatisgarh, Jharkhand and Uttarakhand data is not available before 2000. Thus for these states data of IMR from 2000 to 2016 SRS is being considered. The data of Telangana is not available before 2015 so prediction for Telangana not been made.

3. Results

When we study diagnostic of model we found that the model satisfies the value of Arima (0, 1, 1) for India which is same as the values considered in De *et al.* (2016) ^[8]. So using these results we go for the predicted values for states considered.

3.1 Predicted Values for Andhra Pradesh

Result shows the predicted values for Andhra Pradesh as in 2015 SRS value is 37, in De *et al.* (2016) ^[8] the predicted value was 37 our result shows the predicted value 36 with 95% confidence interval 35-37. For year 2016 SRS value is 34 De *et al.* (2016) ^[8] predicted values 36, in study this value is 34 with 95% confidence interval 33-35. In case of year 2017 the predicted values for De *et al.* (2016) ^[8] 35, in study predicted value is 32 with 95% confidence interval 31-33. For 2018 the predicted value in De *et al.*

(2016)^[8] 34 and in study the predicted value is 30 with 95% confidence interval 29-31. For year 2019 the predicted value in De *et al.* (2016)^[8] is 33 whether in study the predicted value is 28 with confidence interval of 95% 27-30. This shows that the state achieve the target in year 2019.

3.2 Predicted Values for Assam

Result shows the predicted values for Assam as in 2015 SRS value is 47, in De *et al.* (2016)^[8] the predicted value was 52 our result shows the predicted value 49 with 95% confidence interval 47-50. For year 2016 SRS value is 44 De *et al.* (2016)^[8] predicted values 51, in study this value is 47 with 95% confidence interval 45-49. In case of year 2017 the predicted values for De *et al.* (2016)^[8] 50, in study predicted value is 45 with 95% confidence interval 43-47. For 2018 the predicted value in De *et al.* (2016)^[8] 49 and in study the predicted value is 43 with 95% confidence interval 41-45. For year 2019 the predicted value in De *et al.* (2016)^[8] is 48 whether in study the predicted value is 41 with confidence interval of 95% 39-44. This shows that the state does not achieve the target in year 2019. Result also shows for Assam in 2020, in De *et al.* (2016)^[8] the predicted value was 47 our result shows the predicted value 40 with 95% confidence interval 37-42. For year 2021, De *et al.* (2016)^[8] predicted values 46, in study this value is 38 with 95% confidence interval 35-41. In case of year 2022 the predicted values for De *et al.* (2016)^[8] 45, in study predicted value is 37 with 95% confidence interval 34-39. For 2023 the predicted value in De *et al.* (2016)^[8] 44 and in study the predicted value is 36 with 95% confidence interval 33-39. For year 2024 the predicted value in De *et al.* (2016)^[8] is 43 whether in study the predicted value is 35 with confidence interval of 95% 32-38. Result suggest that the predicted values for Assam as in 2025, in De *et al.* (2016)^[8] the predicted value was 42, our result shows the predicted value 34 with 95% confidence interval 31-37. For year 2026, De *et al.* (2016)^[8] predicted value 41, in study this value is 33 with 95% confidence interval 30-35. In case of year 2027 the predicted values for De *et al.* (2016)^[8] is 40, in study predicted value is 32 with 95% confidence interval 29-36. For 2028 the predicted value in De *et al.* (2016)^[8] is 39 and in study the predicted value is 31 with 95% confidence interval 27-34. For year 2029 the predicted value in De *et al.* (2016)^[8] is 38 whether in study the predicted value is 29 with confidence interval of 95% 25-33. Result shows that in 2030, De *et al.* (2016)^[8] predicted value 36 our result shows the predicted value 28 with 95% confidence interval 23-31. This shows that the state achieve the target in year 2030.

3.3 Predicted Values for Bihar

Result shows the predicted values for Bihar as in 2015 SRS value is 42, in De *et al.* (2016)^[8] the predicted value was 39, our result shows that predicted value 41 with 95% confidence interval 38-43. For year 2016 SRS value is 38 De *et al.* (2016)^[8] predicted values 38, in study this value is 39 with 95% confidence interval 36-41. In case of year 2017 the predicted values for De *et al.* (2016)^[8] 37, in study predicted value is 37 with 95% confidence interval 35-40. For 2018 the predicted value in De *et al.* (2016)^[8] is 36 and in study the predicted value is 36 with 95% confidence interval 33-39. For year 2019 the predicted value in De *et al.* (2016)^[8] is 35 whether in study the predicted value is 35 with confidence interval of 95% 31-37. This shows that the state does not achieve the target in year 2019. Result also shows the predicted values for Bihar as in 2020 De *et al.* (2016)^[8] the predicted value was 34 our result shows the predicted value 32 with 95% confidence interval 29-36. For year 2021 De *et al.* (2016)^[8] predicted values 33, in study this value is 31 with 95% confidence interval 27-34. In case of year 2022 the predicted values for De *et al.* (2016)^[8] 32, in study predicted value is 29 with 95% confidence interval 25-33. For 2023 the predicted value in De *et al.* (2016)^[8] 31 and in study the predicted value is 27 with 95% confidence interval 23-31. This shows that the state achieve the target in year 2023.

3.4 Predicted Values for Chhatisgarh

Result shows the predicted values for Chhatisgarh as in 2015 SRS value is 41, our result shows the predicted value 40 with 95% confidence interval 38-42. For year 2016 SRS value is 39, in study this value is 37 with 95% confidence interval 35-39. In case of year 2017 predicted value is 35 with 95% confidence interval 33-37. For 2018 the predicted value is 33 with 95% confidence interval 30-35. For year 2019 the predicted value in study is 30 with confidence interval of 95% 28-30. This shows that the state does not achieve the target in year 2019. In 2020 in our result shows the predicted value is 28 with 95% confidence interval 25-31. This shows that the state achieve the target one year later than 2019.

3.5 Predicted Values for Gujrat

Result shows the predicted values for Gujrat as in 2015 SRS value is 33, in De *et al.* (2016)^[8] the predicted value was 34 our result shows the predicted value 33 with 95% confidence interval 32-35. For year 2016 SRS value is 30 De *et al.* (2016)^[8] predicted values 32, in study this value is 31 with 95% confidence interval 30-33. In case of year 2017 the predicted values for De *et al.* (2016)^[8] 31, in study predicted value is 29 with 95% confidence interval 28-31. For 2018 the predicted value in De *et al.* (2016)^[8] 30 and in study the predicted value is 27 with 95% confidence interval 26-29. This shows that the state achieve the target in year 2019.

3.6 Predicted Values for Haryana

Result shows the predicted values for Haryana as in 2015 SRS value is 39, in De *et al.* (2016)^[8] the predicted value was 34 our result shows the predicted value 36 with 95% confidence interval 35-38. For year 2016 SRS value is 33 De *et al.* (2016)^[8] predicted values 32, in study this value is 34 with 95% confidence interval 33-36. In case of year 2017 the predicted values for De *et al.* (2016)^[8] 31, in study predicted value is 32 with 95% confidence interval 30-34. For 2018 the predicted value in De *et al.* (2016)^[8] 30 and in study the predicted value is 30 with 95% confidence interval 28-32. For year 2019 the predicted value in De *et al.* (2016)^[8] is 29 whether in study the predicted value is 28 with confidence interval of 95% 26-30. This shows that the state achieve the target in year 2019.

3.7 Predicted Values for Jharkhand

Result shows the predicted values for Jharkhand as in 2015 SRS value is 32, result shows the predicted value 31 with 95% confidence interval 29-33. For year 2016 SRS value is 29, in study this value is 29 with 95% confidence interval 26-32. In case of year 2017 the predicted values in study is 27 with 95% confidence interval 24-30. This shows that the state achieve the target before year 2019.

3.8 Predicted Values for Madhya Pradesh

Result shows the predicted values for Madhya Pradesh as in 2015 SRS value is 50, in De *et al.* (2016) ^[8] the predicted value was 51 our result shows the predicted value 49 with 95% confidence interval 47-50. For year 2016 SRS value is 47 De *et al.* (2016) ^[8] predicted values 50, in study this value is 47 with 95% confidence interval 46-48. In case of year 2017 the predicted values for De *et al.* (2016) ^[8] is 49, in study predicted value is 44 with 95% confidence interval 43-45. For 2018 the predicted value in De *et al.* (2016) ^[8] 47 and in study the predicted value is 41 with 95% confidence interval 40-43. For year 2019 the predicted value in De *et al.* (2016) ^[8] is 46 whether in study the predicted value is 39 with confidence interval of 95% 38-40. This shows that the state does not achieve the target in year 2019. Result also shows in 2020, in De *et al.* (2016) ^[8] the predicted value was 45 our result shows the predicted value 36 with 95% confidence interval 35-37. For year 2021, De *et al.* (2016) ^[8] predicted values 43, in study this value is 33 with 95% confidence interval 32-35. In case of year 2022 the predicted values for De *et al.* (2016) ^[8] is 42, in study predicted value is 31 with 95% confidence interval 29-32. For 2023 the predicted value in De *et al.* (2016) ^[8] is 41 and in study the predicted value is 30 with 95% confidence interval 28-31. For year 2024 the predicted value in De *et al.* (2016) ^[8] is 40 whether in study the predicted value is 28 with confidence interval of 95% 26-29. This shows that the state achieve the target in year 2024.

3.9 Predicted Values for Meghalaya

Result shows the predicted values for Meghalaya as 2015 SRS value is 42, our result shows the predicted value 45 with 95% confidence interval 40-50. For year 2016 SRS value is 39, in study this value is 38 with 95% confidence interval 36-49. In case of year 2017 predicted value is 37 with 95% confidence interval 34-48. For 2018 predicted value is 36 with 95% confidence interval 33-48. For year 2019 in study the predicted value is 35 with confidence interval of 95% 31-47. This shows that the state does not achieve the target in year 2019. Result also shows the predicted values in our study for 2020 is 32 with 95% confidence interval 30-47. For year 2021, in study this value is 31 with 95% confidence interval 19-44. In case of year 2022 the predicted values, in study predicted value is 30 with 95% confidence interval 17-44. For 2023 the predicted value, in study is 29 with 95% confidence interval 16-43. For year 2024 the predicted value in study is 28 with confidence interval of 95% 14-43. This shows that the state achieve the target in year 2024.

3.10 Predicted Values for Odisha

Result shows the predicted values for Odisha as in 2015 SRS value is 46, in De *et al.* (2016) ^[8] the predicted value was 48 our result shows the predicted value 45 with 95% confidence interval 44-47. For year 2016 SRS value is 44, De *et al.* (2016) ^[8] predicted values 46, in study this value is 42 with 95% confidence interval 41-44. In case of year 2017 the predicted values for De *et al.* (2016) ^[8] 45, in study predicted value is 41 with 95% confidence interval 40-43. For 2018 the predicted value in De *et al.* (2016) ^[8] 44 and in study the predicted value is 39 with 95% confidence interval 38-40. For year 2019 the predicted value in De *et al.* (2016) ^[8] is 42 whether in study the predicted value is 36 with confidence interval of 95% 34-37. This shows that the state does not achieve the target in year 2019. Result also shows for 2020, in De *et al.* (2016) ^[8] the predicted value was 41 our result shows the predicted value 34 with 95% confidence interval 32-35. For year 2021, De *et al.* (2016) ^[8] predicted value 40, in study this value is 33 with 95% confidence interval 31-34. In case of year 2022 the predicted values for De *et al.* (2016) ^[8] 39, in study predicted value is 31 with 95% confidence interval 30-32. For 2023 the predicted value in De *et al.* (2016) ^[8] is 37 and in study the predicted value is 30 with 95% confidence interval 28-41. For year 2024 the predicted value in De *et al.* (2016) ^[8] is 36 whether in study the predicted value is 29 with confidence interval of 95% 27-30. Result shows the predicted values for state, in 2025, in De *et al.* (2016) ^[8] was 35 our result shows the predicted value 28 with 95% confidence interval 24-30. This shows that the state achieve the target in year 2025.

3.11 Predicted Values for Rajasthan

Result shows the predicted values for Rajasthan as in 2015 SRS value is 43, in De *et al.* (2016) ^[8] the predicted value was 38 our result shows the predicted value 43 with 95% confidence interval 41-44. For year 2016 SRS value is 41 De *et al.* (2016) ^[8] predicted values 36, in study this value is 40 with 95% confidence interval 39-42. In case of year 2017 the predicted values for De *et al.* (2016) ^[8] 35, in study predicted value is 38 with 95% confidence interval 36-39. For 2018 the predicted value in De *et al.* (2016) ^[8] 33 and in study the predicted value is 35 with 95% confidence interval 33-37. For year 2019 the predicted value in De *et al.* (2016) ^[8] is 32 whether in study the predicted value is 33 with confidence interval of 95% 31-35. This shows that Country does not achieve the target in year 2019. In 2020, in De *et al.* (2016) ^[8] the predicted value was 30 our result shows the predicted value 30 with 95% confidence interval 28-32. For year 2021 De *et al.* (2016) ^[8] predicted values 29, in study this value is 28 with 95% confidence interval 25-30. Which interprets that Rajasthan will achieve the target in 2021.

3.12 Predicted Values for Uttar Pradesh

Result shows the predicted values for Uttar Pradesh as in 2015 SRS value is 46, in De *et al.* (2016) ^[8] the predicted value was 46 our result shows the predicted value 46 with 95% confidence interval 45-48. For year 2016 SRS value is 43 De *et al.* (2016) ^[8] predicted value 45, in study this value is 44 with 95% confidence interval 44-45. In case of year 2017 the predicted values for De *et al.* (2016) ^[8] 43, in study predicted value is 43 with 95% confidence interval 41-44. For 2018 the predicted value in De *et al.* (2016) ^[8] 42 and in study the predicted value is 42 with 95% confidence interval 29-31. For year 2019 the predicted value in De *et al.* (2016) ^[8] is 40 whether in study the predicted value is 41 with confidence interval of 95% 40-43. This shows that the state does

not achieve the target in year 2019. Result also shows the predicted values for Uttar Pradesh as in 2020, in De *et al.* (2016)^[8] the predicted value was 39 our result shows the predicted value 39 with 95% confidence interval 37-40. For year 2021 De *et al.* (2016)^[8] predicted values 37, in study this value is 38 with 95% confidence interval 37-39. In case of year 2022 the predicted values for De *et al.* (2016)^[8] 36, in study predicted value is 36 with 95% confidence interval 34-38. For 2023 the predicted value in De *et al.* (2016)^[8] 34 and in study the predicted value is 34 with 95% confidence interval 32-35. For year 2024 the predicted value in De *et al.* (2016)^[8] is 34 whether in study the predicted value is 32 with confidence interval of 95% 30-34. Result suggest that the predicted values for Uttar Pradesh as in 2025, in De *et al.* (2016)^[8] the predicted value was 33 our result shows the predicted value 31 with 95% confidence interval 29-33. For year 2026, De *et al.* (2016)^[8] predicted values 31, in study this value is 30 with 95% confidence interval 28-32. In case of year 2027 the predicted values for De *et al.* (2016)^[8] 30, in study predicted value is 28 with 95% confidence interval 26-31. This shows that the state achieve the target in year 2027.

3.13 Predicted Values for Uttarakhand

Result shows the predicted values for Uttarakhand as in 2015 SRS value is 34, our result shows the predicted value 34 with 95% confidence interval 32-37. For year 2016 SRS value is 33, in study this value is 33 with 95% confidence interval 30-36. In case of year 2017 the predicted value is 32 with 95% confidence interval 29-35. For 2018 the predicted value in study is 31 with 95% confidence interval 28-35. For year 2019 the predicted value in study is 30 with confidence interval of 95% 27-34. This shows that the state does not achieve the target in year 2019. In 2020, our result shows the predicted value 30 with 95% confidence interval 26-33. For year 2021, in study this value is 29 with 95% confidence interval 24-33. In case of year 2022 the predicted values in study 28 with 95% confidence interval 23-23. This implies that the target will be achieved in 2022.

3.14 Predicted Values for India

Result shows the predicted values for India as in 2015 SRS value is 37, in De *et al.* (2016)^[8] the predicted value was 38 our result shows the predicted value 37 with 95% confidence interval 36-38. For year 2016 SRS value is 34 De *et al.* (2016)^[8] predicted values 36, in study this value is 36 with 95% confidence interval 35-40. In case of year 2017 the predicted values for De *et al.* (2016)^[8] 35, in study predicted value is 35 with 95% confidence interval 33-36. For 2018 the predicted value in De *et al.* (2016)^[8] 34 and in study the predicted value is 33 with 95% confidence interval 32-35. For year 2019 the predicted value in De *et al.* (2016)^[8] is 33 whether in study the predicted value is 32 with confidence interval of 95% 31-34. This shows that Country does not achieve the target in year 2019. In 2020, in De *et al.* (2016)^[8] the predicted value was 32 our result shows the predicted value 31 with 95% confidence interval 30-33. For year 2021 De *et al.* (2016)^[8] predicted values 31, in study this value is 30 with 95% confidence interval 29-32. In case of year 2022 the predicted values for De *et al.* (2016)^[8] 30, in study predicted value is 28 with 95% confidence interval 27-30. Which interprets that India will achieve the target in 2022.

4. Discussions and Conclusion

A thorough attempt of study on those states which cover the target of infant mortality of twenty eight per thousand at time point of end of year 2016 is made. Prediction are made up to different time years for different states as they can cover the set target in new national population policy (2017) of 28 infant death per thousand live births up to 2019. results shows that the states which can achieve the target in time of before that are Andhra Pradesh, Gujrat, Haryana, Jharkhand. Assam is 11 years behind the target time points. Bihar shows 4 year behind the target up to set time point. Chhatisgarh is 1 year behind the target of 2019. Result of Madhya Pradesh shows that this state is 5 year behind the target. Odisha is 7 year behind the target time point. Rajasthan shows its 2 year backwardness to target time point to achieve target. Uttar pradesh lies at 8 year behind the target in respect of the time point. Uttarakhad provides that it is 3 year behind the target. Study shows of all over India, The country itself 3 year behind the target of twenty eight infant deaths per thousand live births. This reflect that India can achieve the target if special focus on some states is been made.

Results also reflects that the assumption in previous studies that if some new actual values are different from previously predicted values then whole other predicted values will be changed. It can be seen that when we include data of 2014 to 2016 Sample registration system for infant mortality is introduced the whole predicted values are changed from the prediction of previous study for the same methods. It also suggest that it is better to study the data time to time for better future planning.

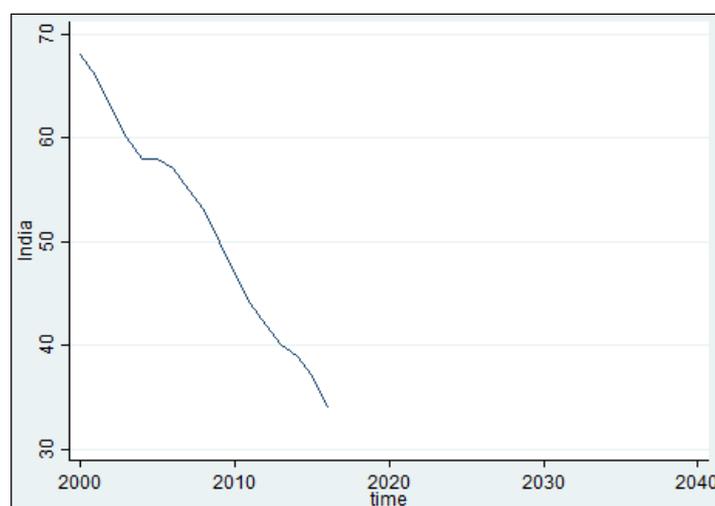


Fig 1: Trend Line of Infant Mortality in India

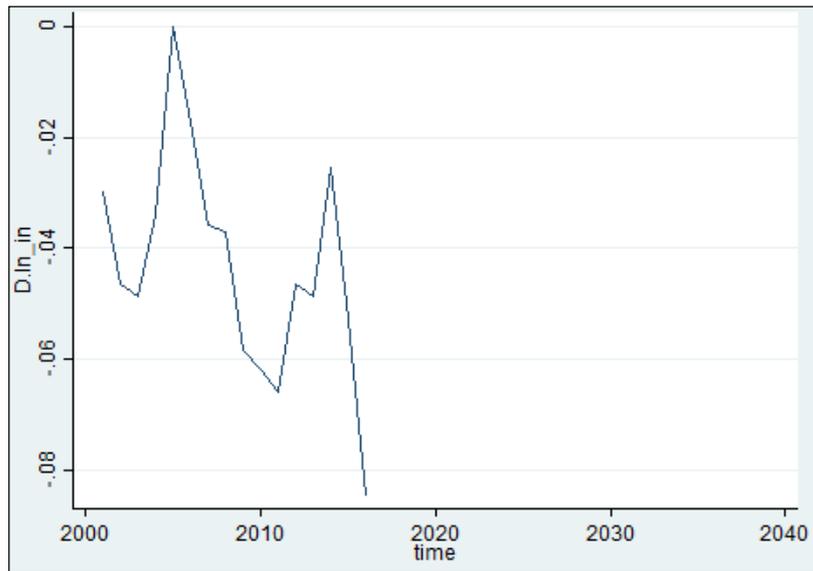


Fig 1: Trend Line of Infant Mortality in India

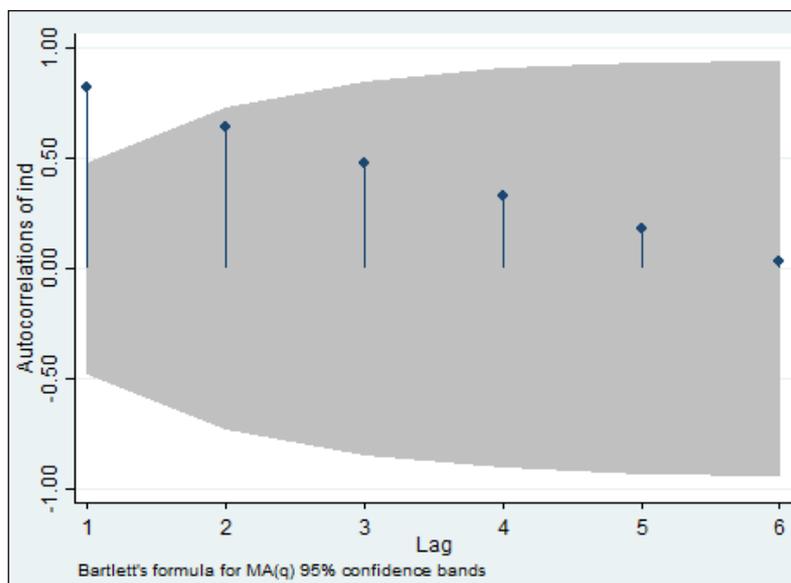


Fig 3: Correlogram of Infant Mortality in India

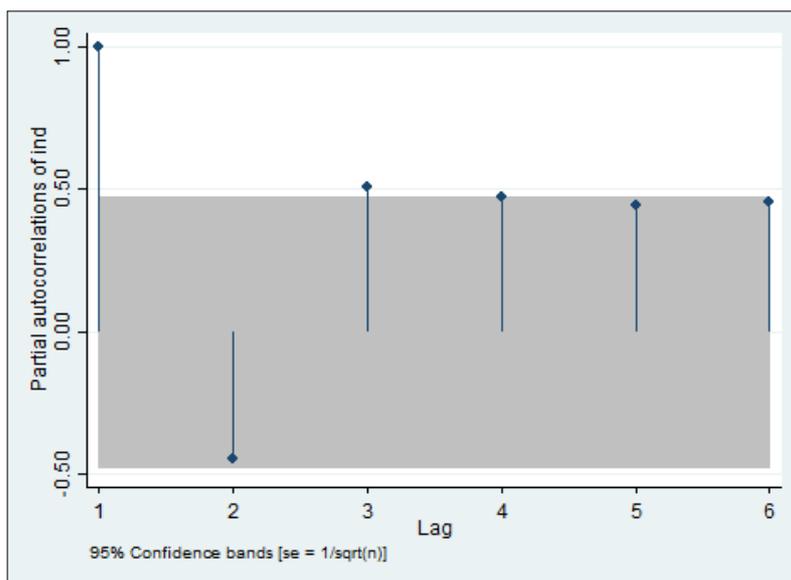


Fig 4: Partial Correlogram of Infant Mortality in India

Table 1: Observed and Predicted Values of IMR in Andhra Pradesh

Andhra Pradesh	Year	SRS values	Predicted values		95% Confidence Interval	
			De et al. (2016)	In Paper	Lower	Upper
	2015	37	37	36	35	37
	2016	34	36	34	33	35
	2017		35	32	31	33
	2018		34	30	29	31
	2019		33	28	27	30

Table 2: Observed and Predicted Values of IMR in Assam

Assam	Year	SRS values	Predicted values		95% Confidence Interval	
			De et al. (2016)	In Paper	Lower	Upper
	2015	47	52	49	47	50
	2016	44	51	47	45	49
	2017		50	45	43	47
	2018		49	43	41	45
	2019		48	41	39	44
	2020		47	40	37	42
	2021		46	38	35	41
	2022		45	37	34	39
	2023		44	36	33	39
	2024		43	35	32	38
	2025		42	34	31	37
	2026		41	33	30	35
	2027		40	32	29	36
	2028		39	31	27	34
	2029		38	29	25	33
	2030		36	28	23	31

Table 3: Observed and Predicted Values of IMR in Bihar

Bihar	Year	SRS values	Predicted values		95% Confidence Interval	
			De et al. (2016)	In Paper	Lower	Upper
	2015	42	39	41	38	43
	2016	38	38	39	36	41
	2017		37	37	35	40
	2018		36	36	33	39
	2019		35	34	31	37
	2020		34	32	29	36
	2021		33	31	27	34
	2022		32	29	25	33
	2023		31	27	23	31

Table 4: Observed and Predicted Values of IMR in Chhatisgarh

Chhatisgarh	Year	SRS values	Predicted Values		95% Confidence interval	
			In Paper	Lower	Upper	
	2015	41	40	38	42	
	2016	39	37	35	39	
	2017		35	33	37	
	2018		33	30	35	
	2019		30	28	33	
	2020		28	25	31	

Table 5: Observed and Predicted Values of IMR in Gujrat

Gujrat	Year	SRS values	Predicted values		95% Confidence Interval	
			De et al. (2016)	In Paper	Lower	Upper
	2015	33	34	33	32	35
	2016	30	32	31	30	33
	2017		31	29	28	31
	2018		30	27	26	29

Table 6: Observed and Predicted Values of IMR in Haryana

Haryana		Predicted values		95% Confidence Interval	
Year	SRS values	De et al. (2016)	In Paper	Lower	Upper
2015	39	34	36	35	38
2016	33	32	34	33	36
2017		31	32	30	34
2018		30	30	28	32
2019		29	28	26	30

Table 7: Observed and Predicted Values of IMR in Jharkhand

Jharkhand			95% Confidence Interval	
Year	SRS values	Predicted Values	Lower	Upper
2015	32	31	29	33
2016	29	29	26	32
2017		27	24	30

Table 8: Observed and Predicted Values of IMR in Madhya Pradesh

Madhya Pradesh		Predicted values		95% Confidence Interval	
Year	SRS values	De et al. (2016)	In Paper	Lower	Upper
2015	50	51	49	47	50
2016	47	50	47	46	48
2017		49	44	43	45
2018		47	41	40	43
2019		46	39	38	40
2020		45	36	35	37
2021		43	33	32	35
2022		42	31	29	32
2023		41	30	28	31
2024		40	28	26	29

Table 9: Observed and Predicted Values of IMR in Meghalaya

Meghalaya			95% Confidence Interval	
Year	SRS values	Predicted Values	Lower	Upper
2015	42	45	40	50
2016	39	38	36	49
2017		37	34	48
2018		36	33	48
2019		35	31	47
2020		32	30	47
2021		31	19	44
2022		30	17	44
2023		29	16	43
2024		28	14	43

Table 10: Observed and Predicted Values of IMR in Odisha

Odisha		Predicted values		95% Confidence Interval	
Year	SRS values	De et al. (2016)	In Paper	Lower	Upper
2015	46	48	45	44	47
2016	44	46	42	41	44
2017		45	41	40	43
2018		44	39	38	40
2019		42	36	34	37
2020		41	34	32	35
2021		40	33	31	34
2022		39	31	30	32
2023		37	30	28	31
2024		36	29	27	30
2025		35	28	24	30

Table 11: Observed and Predicted Values of IMR in Rajasthan

Rajasthan		Predicted values		95% Confidence Interval	
Year	SRS values	De et al. (2016)	In Paper	Lower	Upper
2015	43	38	43	41	44
2016	41	36	40	39	42
2017		35	38	36	39
2018		33	35	33	37
2019		32	33	31	35
2020		30	30	28	32
2021		29	28	25	30

Table 12: Observed and Predicted Values of IMR in Uttar Pradesh

Uttar Pradesh		Predicted values		95% Confidence Interval	
Year	SRS values	De et al. (2016)	In Paper	Lower	Upper
2015	46	46	46	45	48
2016	43	45	44	42	45
2017		43	43	41	44
2018		42	42	40	43
2019		40	41	40	43
2020		39	39	37	40
2021		37	38	37	39
2022		36	36	34	38
2023		35	34	32	35
2024		34	32	30	34
2025		33	31	29	33
2026		31	30	28	32
2027		30	28	26	31

Table 13: Observed and Predicted Values of IMR in Uttarakhand

Uttarakhand		Predicted Values		95% Confidence Interval	
Year	SRS values			Lower	Upper
2015	34	34		32	37
2016	33	33		30	36
2017		32		29	35
2018		31		28	35
2019		30		27	34
2020		30		26	33
2021		29		24	33
2022		28		23	32

Table 14: Observed and Predicted Values of IMR in India

India		Predicted values		95% Confidence Interval	
Year	SRS values	De et al. (2016)	In Paper	Lower	Upper
2015	37	38	37	36	38
2016	34	36	36	35	40
2017		35	35	34	36
2018		34	33	32	35
2019		33	32	31	34
2020		32	31	30	33
2021		31	30	29	32
2022		30	28	27	30

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