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A Study of Indian Infant Mortality with respect to different Socioeconomic, Maternal and Environmental Factors

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Abstract

Infant mortality rates have been declining in India. From 140-120 deaths per thousand live births in the 1970s, it has come down to 44 deaths per thousand live births in 2011. However, the annual rate of decline is less than 2.5 percent. And with this the problem cannot be ignored, as the absolute number of infant deaths is not coming down. India is a large country and includes states with varying levels of economic indicators. They have different levels of development, health infrastructure and per capita income, which results in the different rates of decline in infant mortality. This paper tries to study the impact of these indicators on reducing infant mortality and explained the trends in IMR with respect to different socioeconomic, maternal and environmental factors and also proposed the regression model on a state level. The set of indicators was selected after a thorough review of empirical studies. The analysis suggests that institutional birth and improved sanitation played major role in the reduction of infant mortality.

Key Words- *Infant mortality rate, health economics, socioeconomic status, improved sanitation, institutional delivery*

JEL Classification: JEL:I12- Infant Mortality Rate

1. Introduction:

Children are the most important building blocks of a nation. These are the ones who, when nourished well with resources, become the most valuable human capital, which has the potential to build a strong nation. And so, reducing infant and child mortality are the most important objectives of the development Goals. These rates show the mirrors of the country's socio-economic development, quality of life and also environmental issues related to this. Child mortality helps us to look into the need for expansion of health facilities. These help us to plan our health programme and various policies with differential measures of influence. Latest data on infant mortality rate from the United Nations reflect that the developed countries have performed better than the developing countries. These estimates also state that 10 million infant deaths occur annually throughout the globe while one-fourth of these are reported in India. So, India has good reasons to study the infant mortality rate.

In the last four decades, there has been significant decrease in infant mortality rates in India. But it is not at all admirable in comparison to the Southeast Asian Countries. Countries like Bangladesh, Sri Lanka, and Malaysia etc. have outperformed India in controlling infant mortality and reducing it. After the declaration of 1978, the Government of India confronted the national goal of attaining the infant mortality rate of 60 (out of 1000 live births) by the year 2000. In the light of this, substantial resources have been put in child survival programmes over the last 35 years. The sixth and the seventh five year plans boosted the health and environment programmes to attain this goal. In 1977, maternal and child health became an integral part of the Family Welfare Programme. The integration was based on the logic of reduction in child and infant mortality through the reduction in the birth rate and contributions to safe motherhood (MoHFW, 1998).[1]

Infant mortality rates have been declining in India. From 140-120 deaths per thousand live births in the 1970s, it has come down to 44 deaths per thousand live births in 2011. However, the annual rate of decline is less than 2.5 percent. And with this the problem cannot be ignored, as the absolute number of infant deaths is not coming down. Studies of early childhood

indicate that the sex differential prevails there too. And the regional differential is favourable to urban areas vis-à-vis rural India. In the last decades, the average annual infant mortality rates were 64.5 and 39 for the rural and urban areas respectively.[2] Some of the states in India have continuously performed better, like Kerala. Southern states have better performance and have succeeded in reducing the infant mortality rate compared to the northern states. Still today, there is one death for every twenty children at national level, one death for every eighteen children at rural level and one death for every twenty nine children at urban level, as estimated by the Sample Registration System.

India is a large country and includes states with varying levels of economic indicators. They have different levels of development, health infrastructure and per capita income, which results in the different rates of decline in infant mortality and maternal mortality rates. Apart from medical causes of death, a major role is played by the social, economical, geographical, demographical, health infrastructure and environmental determinants in explaining the differential rate of decline in child mortality.

2. Literature review:

Infant mortality is a very sensitive issue which is also addressed by the Millennium Development Goals. In health economics, the issue of infant mortality is generally looked through micro and macro perspectives. The socio-economic indicators, demographic indicators and the environmental indicators normally give better insight to individuals or households while other indicators like growth, public expenditure on health, health infrastructure provide a broader view. Lots of empirical health studies have analyzed the various determinants of the infant mortality and maternal mortality throughout the world and in India too. Access to health facilities, immunization, income level, education, nutritional health and economic growth are some of the factors that have been found to determine infant mortality. This clearly reflects that the public policies intended to stimulate these issues through various channels have helped to reduce the mortality rate. Added to this, environmental factors like better sanitation, clean cooking fuel, electricity and access to safe drinking water have a positive impact on improving the health of the mother and her child. Various analysts have pointed out that government expenditure on health and building infrastructures lead to betterment of society. So the

different organizations like the World Bank, UNICEF etc have focused on these factors closely.

Caldwell (1979) in his earlier studies in Nigeria started a debate over the importance of maternal schooling (independent from years of schooling) for reducing child mortality.[3] Sen and Ostline (2007) studied the difficulties in access to health care facility in developing countries by women. Women with better education and empowerment have better access to the health facilities with limited barriers. While the physical and economical barriers prevent woman with no or less education and empowerment from accessing the health services.[4]

Amin(1990) studied the effects of women's status on sex differentials in infant mortality. The analysis was based on two broad principles: a) women's power, autonomy and control over resources enhance their ability to provide high quality care for children. b) Women's economic and social status determines the value of daughters to parents. The analysis found that education is strongly associated with reduced mortality. Specifically, educated mothers utilized resources more efficiently for their children's health and they do it so in a preferential manner to benefits more valued children.[5] Pande and Astone, (2007) tried to explained son preference with NFHS data for 1992-93. Their analysis showed that the women's education played an important role in the determination of son preference. Regardless of family size, women with secondary or higher level education were consistently and significantly affiliated with the weaker son preference as compared to less educated or illiterate women.[6]

Maternal characteristics that are mainly discussed in most of the literature are mother's age at child birth, birth order, preceding birth order, child sex, assessment of high risk birth, maternal nutrition, and the nature of assistance at childbirth. Child mortality appears to be higher for children born to mothers' age less than 20 years and lowest in the age group of 20-24 ages. For the age between 25-34 years, infant and child mortality remains low and above 35 years it increases sharply. This shows that it follows U shaped relation between the mother's age at birth and child mortality (UNICEF: The Infant and Child Mortality India Report, 2012). Syamala (2004), who studied the relation between the socio demographic factors and child survival in Goa with survey data from "The Levels of Fertility and Mortality in Goa" conducted

by International Institute for Population Sciences, shows similar outcomes as expected.[7]

Quamrul, Islam and Hossain (2010) used contingency analysis and logistic regression to show the relation between the breastfeeding, mother's age at child birth and birth order in Bangladesh. Their study reflects that the mortality was higher when women were married before 15 years of age and when the mother had late marriage but failed to breastfeed their baby. The logistic regression shows that neonatal mortality is highly influenced by breastfeeding practices but in post neonatal mortality all the high risk factors like age at marriage, order of birth, birth interval has significant effects.[8]

Infant mortality has some relation to environmental factors like access to safe drinking water, access to proper sanitation facility, use of clean cooking fuels etc. One of the major diseases like diarrhea, the second largest killing disease for children, is responsible for killing 7, 60,000 children per year throughout the globe (WHO report). Access to safe drinking water is higher in urban than in rural areas. Throughout the developing world, access to improved drinking water sources in the rural areas remains unacceptably very low. Coverage of safe drinking water has remained stagnant for urban areas from 1990-2004 at 95%, whereas in rural area coverage increased to 73% in 2004 from 64% in 1990. In 27 developing countries, less than 50% of the rural population has access to improved drinking water (WHO and UNICEF joint reports on water and sanitation, 2006). In India, between 1981 and 2006, families having access to safe drinking water had lower mortality than families not having it. It has been observed that the unsafe drinking water problem and poor socio- economic factors go side by side and have adverse effects on infant mortality. Environmental degradation is matter of concern in present time. Due to massive environmental degradation in the Central Asian Republic region, there has been excessive mortality observed in this area. Studies on child mortality and fertility in 61 developing countries, while controlling for exogenous socio- economic impact, health and environmental variables, have shown that it has influential impact on health and mortality (Franz and Roy, 2006).[9]

In developing countries, access to an improved toilet is an important determinant of child and infant mortality. In households that do not have such access, children have higher exposure to diarrhea and other intestinal

problems in contrast to children in households that do have such access (Serrano and Puffer, 1973).[10] The analysis also indicates that sanitation facility alone is not sufficient to prevent such disorders. It requires safe drinking water access and improved sanitation facility coupled with hygienic conditions to have a demonstrable impact on mortality (UNICEF: The Infant and Child Mortality India Report, 2012). Khanna, Kumar, Sreenivas et al (2003) found the principal causes of mortality in India to be low birth weight, birth injury, diarrheal diseases and acute respiratory infections. The number of male and female infants dying due to asphyxia, immaturity and congenital anomalies were matched and no significant difference was pointed out. However, in terms of the preventable and treatable illness of diarrhea, twice the number of deaths was recorded for girls as compared to male infants.[11]

In this paper we first examine the level and trends of the infant mortality rate from 2001-2011 and how the states are performing in these periods. Then we further examine the role of various indicators which leads to decline in IMR, i.e. to analyze the effects of socioeconomic characteristics, maternal and demographic characteristics and environmental factors in reducing infant mortality rate.

3.1 Data source:

To fulfill our objectives of study, secondary data from the Sample Registration System (2001-2011) and third round of NFHS-III (2004-05) has been used. In NFHS-III, more than 2, 30,000 women age 15-49 years and men age 15-54 years were interviewed by 18 research organizations throughout the India. Whereas, the SRS survey provides reliable estimates of the birth, death and infant mortality rates.

3.2 Descriptive analysis:

In this chapter, we analyze IMR trends of the major states of India with respect to different environmental, socio economic & demographical factors. Different factors affect IMR in different ways. We tried to establish the relations between the mortality rates with respect to different factors in the context of India. In this, we have undertaken the following analysis using SRS estimates of IMR & NFHS-III reports.

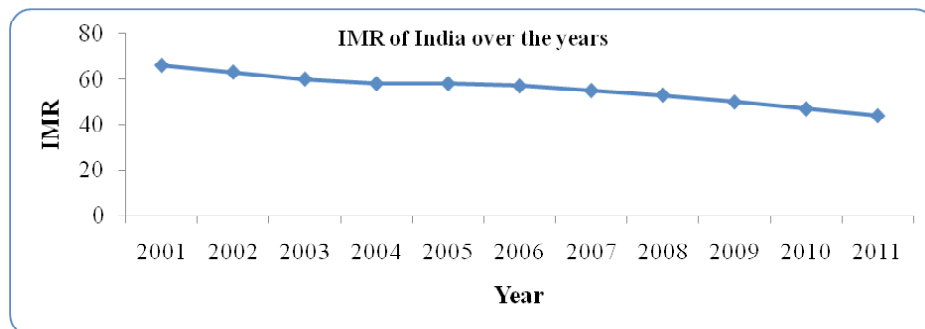## IMR & Different Factors Analysis:

Fig 1: IMR of India over the years (2001-2011)

IMR of India has a decreasing trend from 2001 till now. The rate of decrease was low during 2004-06, but from 2008 it shows more rapid decrease.

The IMR has decreased for all the major states over the years. The states with higher IMR than others are Madhya Pradesh, Orissa, Rajasthan, and Uttar Pradesh. Kerala has significantly lower IMR over the years. Except at few points, the decreasing rate of IMR is significant which shows that all the states have decreasing trend over the years.
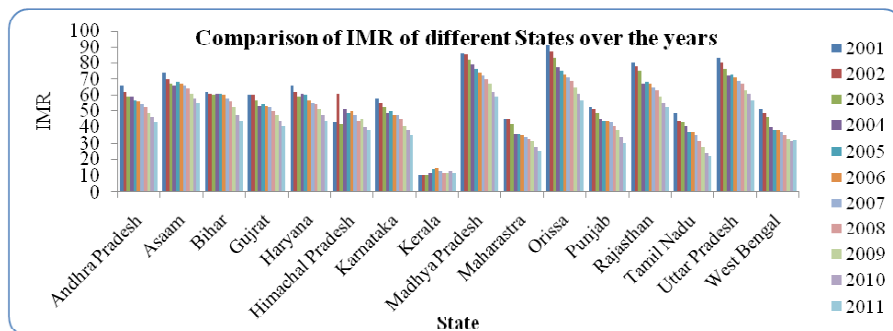
Fig 2: Comparison of IMR of Different States (2001-2011)

From Fig 2, it can be observed that Assam, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh have always higher IMR than IMR at national level for all the years. Bihar & Haryana have equal or higher IMR than the national level IMR for the time period 2004-2010. The states Kerala, Karnataka, Punjab,

Tamil Nadu, and West Bengal have lower IMR than national level IMR over the years.

Different analyses are performed based on different factors such as wealth index, delivery place, region wise etc. These analyses are performed based on NFHS-III data, using state reports mainly.
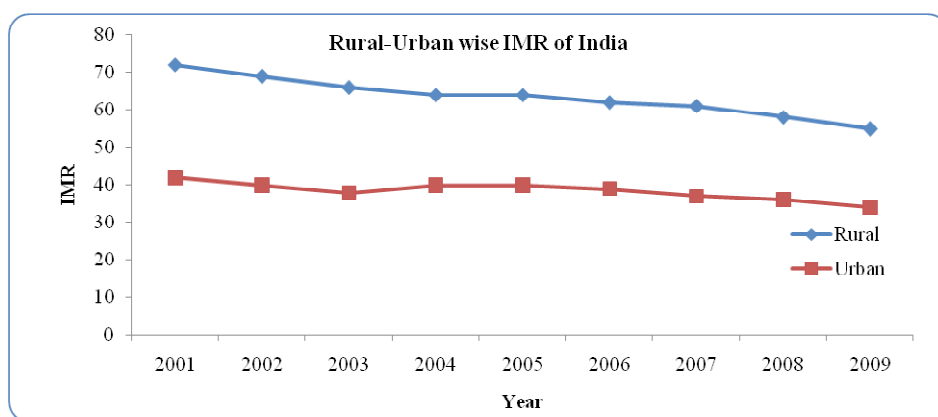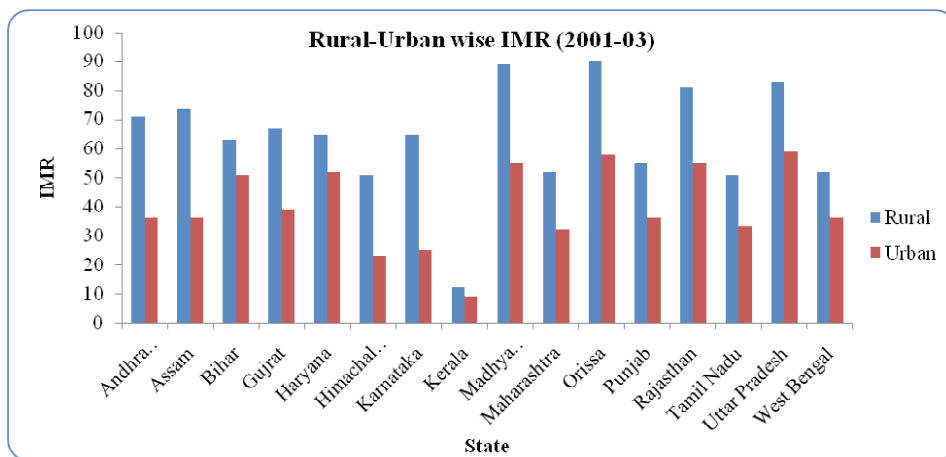

Fig 3: Rural-Urban wise IMR of India (2001-09)
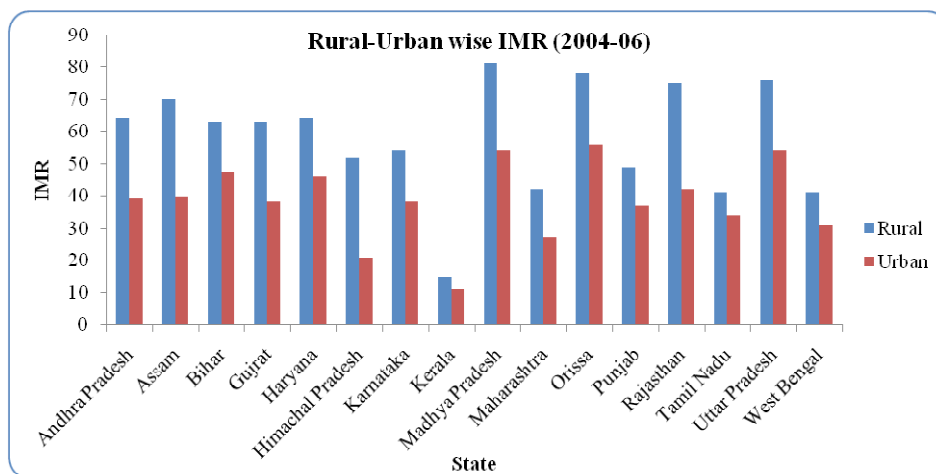

Fig 4: Rural-Urban wise IMR of Different States (2001-03)

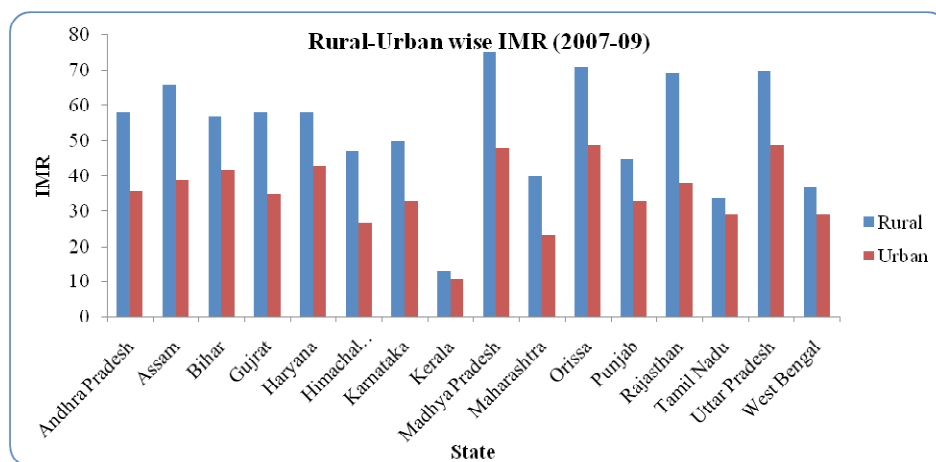**Fig 5: Rural-Urban wise IMR of Different States (2004-06)**

Fig 6: Rural-Urban wise IMR of Different States (2007-09)

Rural IMR in India has always been much higher than urban IMR over the years. Though the trends are continuously decreasing over the years for both rural & urban, the difference is still very high. The difference is least for Kerala and Delhi whereas this is very high for Rajasthan and Orissa.
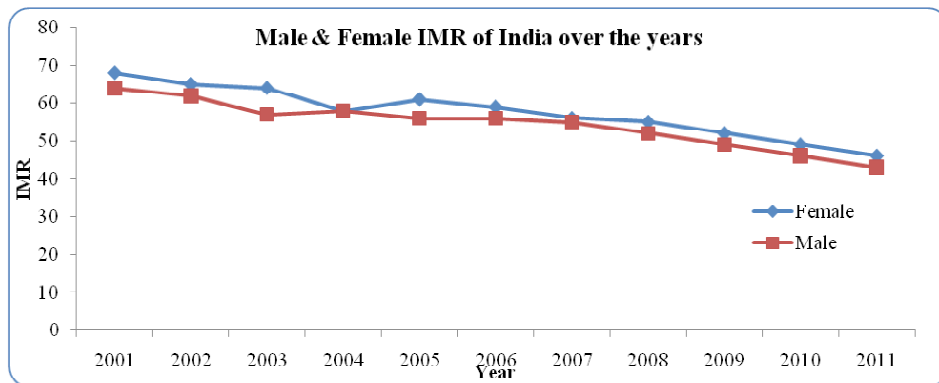
Fig 7: Male & Female of India over years (2001-11)

IMR of females has been higher than that of males in India over the years. Both male and female IMR show decreasing trends as observed.
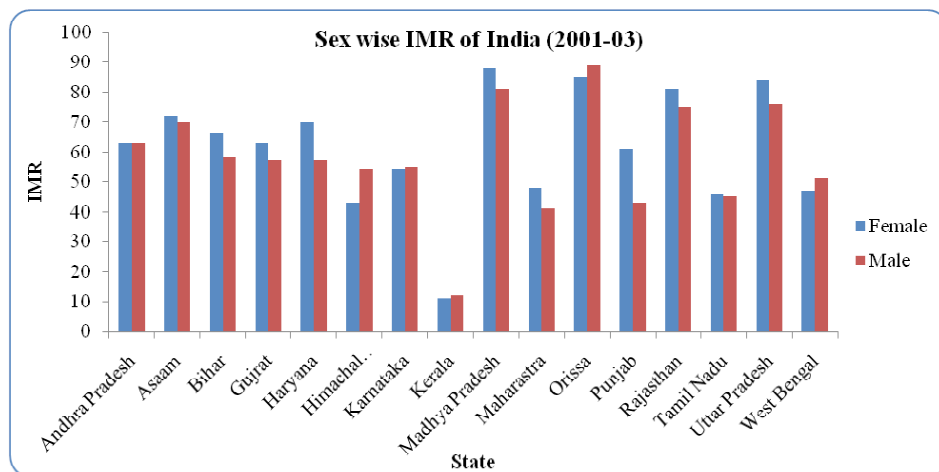

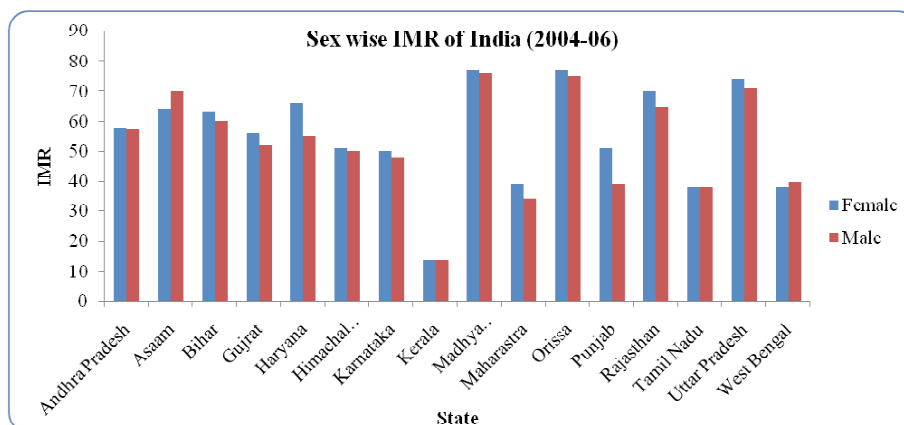**Fig 8: Sex wise IMR of Different States of India (2001-03)**

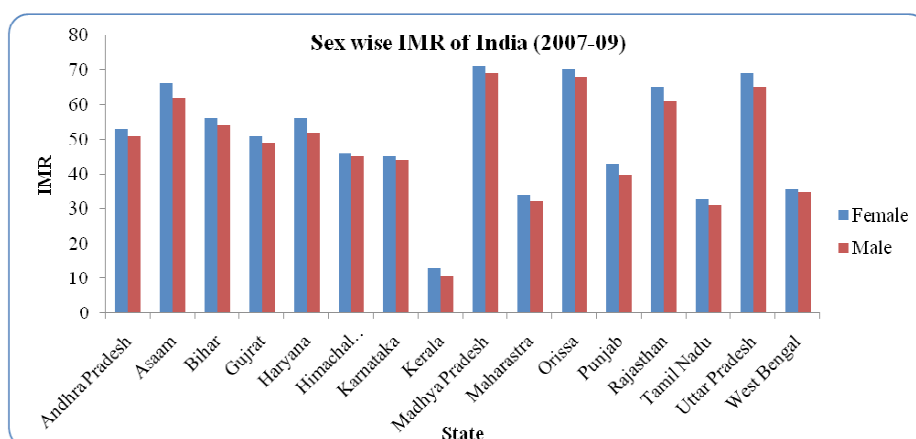**Fig 9: Sex wise IMR of Different States of India (2004-06)**

Fig 10: Sex wise IMR of Different States of India (2007-09)

In the Fig 8, Fig 9 & Fig 10: Male & Female IMR for different states over different time periods are shown. It is observed that in the years 2001-03, Bihar, Haryana, Punjab had higher IMR for female than male. In Himachal Pradesh, male IMR was higher than female in the early years (2001-04), but in recent years the female IMR is more than male IMR. Andhra Pradesh, Gujarat has higher female IMR than male in recent years. From this, we can conclude that gender gap exists in different states in context of IMR.

Different analyses are done between IMR (2005-06) of different states & different state level indicators of the same time period, such as percentage of household with improved sanitation, percentage of delivery by professional health personnel, percentage of household below poor wealth index etc. The Spearman's Rank Correlation coefficient between rank of the IMR of states & rank of states in terms of state indicator is computed. This measure is used to determine the statistical dependency between two variables. The range of the measure is between -1 to 1. If there is a negative association between two variables, then the value should be negative & if there is a positive association between two variables then the value should be positive
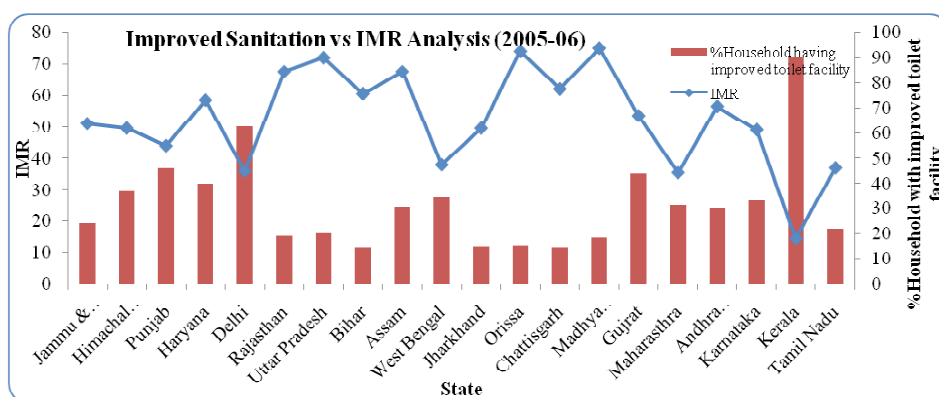

Fig 11: Households with Improved Sanitation vs IMR Analysis (2005-06)

Sanitation facility is directly related to hygienic status of people which effects health too. Fig 11 supports the fact that states with more improved sanitation facility have lower IMR. The Rank Correlation between IMR of different states & percentage of household with improved sanitation of those states is -62%. The measure of Rank correlation is high enough to support the conclusion for the period (2005-06).
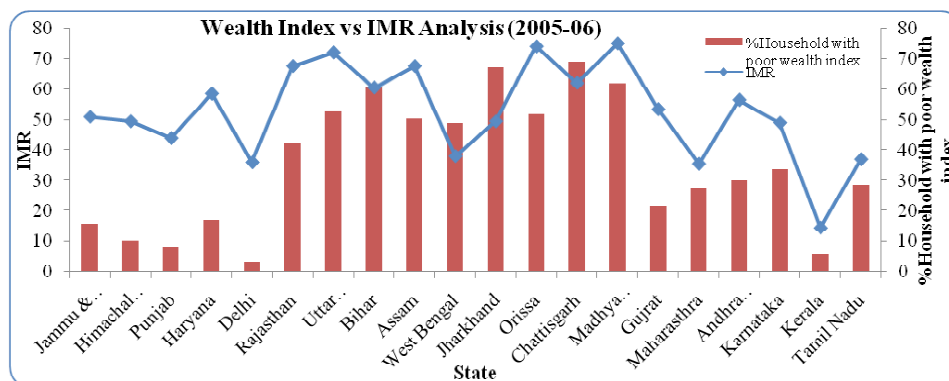
Fig 12: Household with Poor Wealth Index vs IMR Analysis (2005-06)

As shown in the Fig 12, the states with higher percent of household with poor wealth index also have higher IMR. Health care is directly related with the financial status of the household. Households with poor wealth index often cannot afford health treatment or child care after delivery. The Rank Correlation between IMR of different states & percentage of household with poor wealth index of those states is 65%. The measure of Rank correlation is high enough to support the conclusion for the period (2005-06).
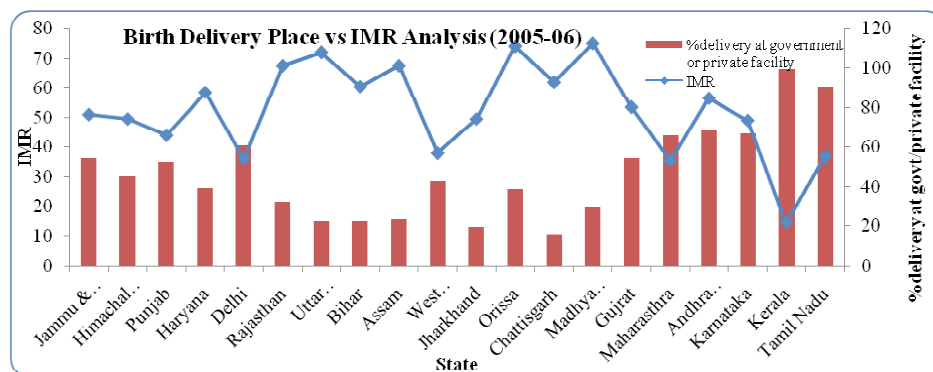

Fig 13: Birth Deliver Place vs IMR Analysis (2005-06)

From Fig 13, it can be observed that in states where there is a higher proportion of delivery at Government/ private facility, the IMR is lower

compared to others. As, different government/ private hospitals are equipped with better instruments, doctors, nurses, the delivery process is more safe & efficient. The Rank Correlation between IMR of different states & percentage of delivery in government/private hospitals of those states is -70%. The measure of Rank correlation is high enough to support the conclusion for the period (2005-06).

3.3 State Level Analysis

In this section, we have modelled Log (IMR) (IMR is converted into a percentage) with different demographical, environmental, socio economic factors by linear regression method at state & district level. We have considered the factors based on our intuitive sense & availability of the data in NFHS-III reports. Log (IMR in percentage) of 2005-06 for different states are considered as the dependent variable for modelling purposes. Different independent variables are considered to fit the model. The purpose of the modelling is to determine which combination of dependent variables has a significant effect on IMR at the state level. IMR is calculated as the average of IMR (in percentage) based on SRS data of 2005-06. Different variables are considered from NFHS-III (2005-06) state reports, RBI Planning Commission reports. [12]

The model is developed based on Linear Regression. Different environmental, socio-economic, demographical variables are considered for model development.

The final regression model is as follows:

$$\begin{aligned}
\text{Log(IMR)}_{\text{Estimated}} \\
= -1.8 + (-0.005 \times \text{inst\_birth}) + (-0.011 \times \text{child\_food}) \\
+ (-0.008 \times \text{improved\_sanitation}) + (0.005 \times \text{BPL\_card}) \\
+ (-0.004 \text{private\_hosp})
\end{aligned}$$

Variable Name	Description	Coefficient	Std Error	t-stat	p-value
inst_birth	Percentage of institutional births	-0.005	0.0027	-1.7441	10.31%
child_food	Percentage of children age 6-9 months receiving solid or semi-solid food and breast milk	-0.011	0.0050	-2.2292	4.27%
improved_ sanitation	Percentage of household having improved sanitation facility	-0.008	0.0032	-2.4258	2.94%
BPL_card	Percentage of household owning a BPL card	0.005	0.0034	1.6142	12.88%
private_hosp	Percentage of household covered by private medical sector	-0.004	0.0022	-1.6812	11.49%

Following Fig 14 is the graph of observed & estimated IMR (in percentage) for different states:
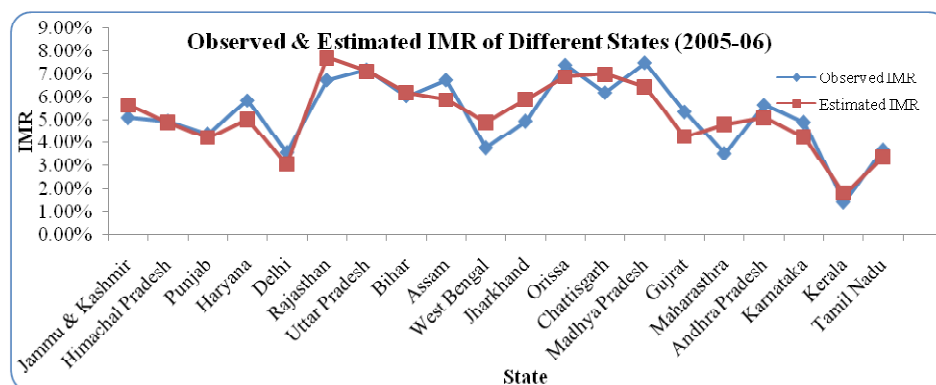

Fig 14: Observed & Estimated IMR of Different States (2005-06)

From Fig 14, it is observed that the "observed" & the "predicted" values are very close to each other & the model is fitted well enough.

Following are the different validation measures computed based on the observed IMR & estimated IMR:

R-Square	Correlation	MSE	RMSD	MAD
77.12%	87.82%	0.01%	0.74%	0.64%

The R-square & correlation coefficient values are high, so it can be concluded that the model fitted values & observed values are highly correlated as expected. For other measures all the values are very small, on the average the residuals between the fitted model & observed values would be very small in absolute term. From these values, we can say that the fitted model is good in terms of predicting IMR.

State level analysis of this combination of factors has good impacts on infant mortality rate. It shows that the factors like institutional birth , children (aged 6-9 months) receiving breast milk, solid and semi- solid food, household with improved sanitation facility, household owning BPL card and households covered by private medical sector have a significant impact on the infant

mortality rate. Institutional birth is negatively correlated to infant mortality rate, i.e., percentage of institutional delivery increased there will be a decrease in infant mortality rate (for 1% increase in institutional delivery, Log(IMR) would be decreased by 0.005, hence the decrease in IMR too). Most of the infant's death at delivery time caused due to last minute complication. Regular checkup and better health care facilities in the medical institution provide good precautionary measures for safe delivery. Availability of necessary equipment and professionals in private and public hospitals help in taking good care of maternal problems at delivery time. And, it is advisable to seek safe delivery from professionals to avoid unpredicted problems during the pregnancy periods. But, the demographic and social- economic constraints can repel people from using the medical institutions. For them, government policies like Janani Suraksha Yojna (JSY), Shishu Yojana Programme and ASHA worker models gave an incentive to opt for the safe institutional delivery system. Public Health Centre (PHC) at village level also helps in safe delivery by professionals. All these policies help the people to opt the safe delivery system and reducing the chances of infant and maternal mortality.

Children (aged 6-9 months) having breast feeding, solid and semi-solids foods have positive impacts in reducing the infant mortality (for 1% increase in the variable, Log(IMR) would be decreased by 0.011, hence the decrease in IMR too). (Quamrul, Islam and Hossain, 2010) studies also show that the significance of breastfeeding in early stage of child life in reducing the infant mortality in Bangladesh. Similar finding comes from this model in terms of breast feeding. The breast feeding milk is rich in nutrients and antibodies which help to protect the child in earlier stage. This milk contains the right amount of fat, sugar, water and protein and helps the children to attained healthy growth. This also protects from respiratory illness as well as a diarrhea problem which are the two major problems that leads to infant death. Breast feeding helps both mother and child. And, it also helps financially by lowering the health care cost.

Improved sanitation facility, an environmental factor, has a significant impact on reducing the infant mortality rate (for 1% increase in household with improved sanitation facility, Log(IMR) would be decreased by 0.008, hence the decrease in IMR too). Children in household with improved sanitation and better hygiene facilities have lower risk of mortality. (Serrano

and Puffer, 1973) shows that the improved sanitation facilities in the third world countries have potential influence in reducing the infant mortality. Although the Total Sanitation Facility (TSC), a flagship programme of the Indian government has been able to improve average health but due to substantial incomplete coverage, the true potential of sanitation programme is far from realisation. On the other hand, Nirmal Gram Puraskar (NGP) programme provide incentives to the village government and have performed better where it required the most. The potential benefit of the sanitation coverage on infant mortality is enormous. So, policy should be directed to increase the coverage of improved sanitation facilities and better implementation of this will have a good impact on infant mortality rate.

Households owning below poverty line (BPL) card have prominent influence on the infant mortality rate in a negative direction (for 1% increase in household holding BPL card, Log(IMR) would be increased by 0.005, hence the increase in IMR too). The number of households owning BPL card increased, the mortality will also increase. The BPL card helps the lower strata of income group with limited means to have food and other goods at concession rate. This is due to lack of nutritious food, basic amenities and accesses to the health centre deteriorate the problem. Although, Janani Suraksha Yojana (JYS) and its relation with BPL card household could have a positive effect on infant mortality. BPL card eases the problem of food and JYS- an integrated package helps the child and the mother in safe delivery. But, the overall impact is not favourable and infant mortality increases with the increased in BPL card holders. There is potential to improvise the situation through efficiency and efficacy of policy measures understanding the needs of the low income group people.

Increase in households covered by a private medical center has significant impact in reducing the infant mortality (for 1% increase in household covered by private medical sector, Log(IMR) would be decreased by 0.005, hence the decrease in IMR too). The recent growth of private sector in the medical field, with better sophistication and equipment, has a good indicator for the health infrastructure. Both the government and private medical institution have done well while the expansion of the latter with the better facility and caring units have massive impact on the health care. The R & D (private sector) team helps in developing medical tools and necessary medicine and well supported

by government policies helps in growing of private medical centre recently. The Cost to access private medical centre is moderately high, but still has good opportunities in creating better health facilities. The policy should be focused on creating environment for both the institution to reach the mass population and helps to attained nation with less health problems.

If we look at these factors closely, we found that the preventive measures for the mother's health should be more in focus to curb the infant mortality and maternal problem. So, it is prudent to focus on the mother's problem for coming generation and designed the policy such that it has inclusive effect on children's health too. Since, the problem of infant mortality and maternal mortality has an impact on the future of the human capital of the nation, so it needs to diversify our efforts to optimal level to get the desired result in health related issues of infant mortality.

References

1. Family Welfare Statistics In India, 2011: *Statistics Division: Ministry of Health and Family Welfare, Government of India.*

2. IIPS (2007): "*National Family Health Survey (NFHS-3), 2005–06": India: Volume I*, International Institute for Population Sciences (IIPS) and Macro International. 2007. Mumbai: IIPS.

3. Caldwell, John C. (1979): "*Education as a factor in mortality decline: An examination of Nigerian data*", Population Studies 33, no. 3: page 395-413.

4. Sen Gita, Piroska Ostlin (2007): *"Gender Inequity in Health".* WHO Report- Improving Equity in Health by Addressing Social Determinants, 2011, Chapter 3, page 59-87.

5. Amin, S. (1990): "*The effect of women's status on sex differentials in infant and child mortality in South Asia*", Genus 46, no. 3-4: page 55-69.

6. Pande, R.P. And N.M. Astone (2007): "*Explaining son preference in Rural India: The Independent role of structural versus individual factors*". Population Research and Policy Reviews, Vol. 26, Issue 1, page 1-29.

7. Syamala, T.S. (2004): "*Relationship between Socio-Demographic factors and child survivals: Evidence from Goa, India".* Indian Journal of Human Ecology, Vol.

16, No.2

8.   Quamrul, H.C., Rafiqul Islam & Kamal Hossain (2012): "*Effects of Demographic characteristics on Infant and Child Mortality*". Current Research Journal of Biological Science, vol. 2, Issue 2, page 132-138.

9.   Franz, Jennifer S. and Felix Fitz Roy (2006): "Child Mortality and Environment in Developing Countries". Population and Environment, vol. 27, No. 3, page 263-284.

10. Serrano,C.V. & Puffer,R.C.(1973): "*Anaemia and Plasmodium falciparum infections among young children in a holoendemic area, Bagamoyo, Tanzania. Patterns of mortality in childhood*". Scientific Publication no. 262 Pan American Health organization Washington,DC.

11. Khanna, R., A. Kumar, J.F. Vaghela, V. Sreenivass and J.M. Pulley (2003): "*Community Based Retrospective Study of Sex in Infant Mortality in India*". British Medical Journal, Vol. 325, No. 7407, page 126-128.

12.   Expenditure on Medical and Public Health and Family Welfare from RBI data source (2010-11).