Paper

Title: Estimation and Analysis of Child Mortality for Indian States through a Bayesian Approach

Reetabrata Bhattacharyya
PhD Student,
Population Studies Unit,
Indian Statistical Institute

Arni S.R. Srinivasa Rao*
Assistant Professor
Population Studies Unit,
Indian Statistical Institute
203 B.T. Road, Kolkata,
INDIA 700108
Email: arni@isical.ac.in
Tel: +91-33-25753511
Web page: http://www.isical.ac.in/~arni

***Corresponding Author**

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Summary of the Extended Abstract

Proportion of children dying up to four years of age is one of the important health indicators in terms of impacts of overall health and nutritional programs by Indian government. Probabilities of child deaths among Indian states are varying from 0.001 to 0.0288 according to NFHS –III (National Family Health Survey – III). Based on three rounds of national family health surveys and sample registration systems data in India, we have performed Bayesian analysis through which, we estimated *posterior probabilities* for all the major states. We also correlate these probabilities with socio economic status of Indian States. Interpretation based on Bayesian estimators, justifies that there is a link between the socio economic indicators, mothers education and age of the mother. Improving the age of the mother at the time of delivery in constructing *prior probabilities* has improved our understanding of posteriors.

Background:

During the last two decades, India has experienced moderate reduction in child mortality. Child mortality rates up to age four is around 20 per 1000 live births during 2001 to 2007 in India (SRS Reports, 2001 - 2007). United Nations warms that Indian child deaths are mostly due to malnutrition and needs actions for further reduction in number of children dying before reaching age five (Voanews, 2007) Analysis conducted based on second round of national family health surveys shows that average education level of mother is strongly related to child mortality in India (Kravdal, 2007) . Although, there were studies which indicate malnutrition, poverty, mother's education (first and second phase of national family health survey, 1998-1999), the proportion of deaths below age one has reduced several Indian states, viz, Chhattisgarh, Maharashtra, Orissa, Gujarat and Punjab (third phase of national family health survey, 1998-1999). According this survey, there was also improvement in nutritional status of children in several states. The declines in child mortalities in various states cannot be authenticated because these rates are computed only with the cross sectional survey data and without any information on previous knowledge on factors caused the decline.

Child mortality rate is calculated directly from specially designed surveys, age specific death numbers available from vital registration system. When direct rats are not available, indirectly, one can obtain using life table techniques, probability of death up to age four and then convert the probability into mortality rate. There are several statistical estimation procedures, namely, regression approaches (Trussell and Preston, 1982, Mauskopf, 1983), cohort approaches (Schoen, 1970, Sullivan, 1972) (including life table approaches to obtain probabilities that a newly born individual will die before attaining age one and before attaining age five, i.e. ${}_1q_0$ and ${}_5q_1$ respectively. Majority of the methods do not consider any assumptions or model the set of causes that have contributed in arriving the current data which is used for statistical analysis. We make use of some additional knowledge on the process that helps to arrive the child mortality data through a Bayesian approach in estimating posterior probabilities.

In this paper, we have extracted data from three rounds of national family health surveys in India, sample registration system, registration general of India to construct credible regions for the child mortality patterns by major Indian states using Bayesian approach. However, in this extended abstract, we mention overview of the methods and results.

Methodology

Consider three national family health surveys conducted in India during 1991-92, 1998-99 and 2005-2006, Let *M* denote the observed child mortality data, which is being generated by random mechanism, (say, $p(M/\Phi)$), where $\Phi \in \Theta$.

Let $p(\Phi)$ be the prior information on child mortality in various states, $I^{\Phi}\{T, p(\Phi)\}$ be the information function (similar to Shanon's general information theory), then

$$I^{\Phi}\{T, p(\Phi)\} = \int_T \int_\Theta (p((\Phi)\log\frac{p(k,\Phi)}{p(k)p(\Phi)}d\Phi dk$$

$$= E_{k/\Phi}\left[\int_\Theta p(\Phi/k)\log\frac{p(\Phi/k)}{p(\Phi)}do\right]$$

Here we assume, that $I^{\Phi}\{T, p(\Phi)\}$ is expected to be obtained by complete data M. We use sharp prior knowledge as well as conventional Bayesian approach. (See Lindley, (1957), Bernardo and Smith (1994)). In the absence of sharp prior, we used intrinsic approach. Suppose $p_1(y/\alpha), p_2(y/\beta)$ are two alternatives for the data $y \in M$. In general, intrinsic discrepancy $\delta(p_1, p_2)$ is minimum expected log-likelihood ratio, in favor of the true sampling distribution. We use conventional definition of $\delta(p_1, p_2)$ as follows:

$$\delta(p_1, p_2) = \min\left\{\int_M p_1(y)\log\frac{p_1(y)}{p_2(y)}dy, \int_M p_2(y)\log\frac{p_2(y)}{p_1(y)}dy\right\}$$

As an example to our study, consider child mortality in 2005-06 in India as 0.0743 Let C_m be the event of child mortality in the population, and *E* be the event that the mother of the child is educated (primary, middle and high school and above). We have $P(C_m/E) = 0.551$ and $P(C_m/\overline{E}) = 0.449$ We have estimated posterior probability $P(E/C_m, I^{\Phi})$. We have considered mechanisms of generating the data on child mortality. Bayes theorem on inverse probabilities, gives us

$$P(E/C_m, I^{\Phi}) = \frac{P(C_m/E)P(E/I^{\Phi})}{\int_E P(C_m/E)P(E/I^{\Phi})dE}$$

We have interpolated child mortality values for the years where NFHS survey was not conducted using Lagrange interpolation formula. NFHS provide us the data on age specific death rates, so using Reed and Merrell (1939) method, we have computed probabilities of death during 0 to 4 years for newly born babies.

Results and discussion:

We have presented a partial analysis of our results in this section. Apart from the impact of educated women on child mortality, we considered several socio economic variables into our study. The formula for $P(E/C_m, I^{\Phi})$ consists of several probabilities (also known as conditional measures of uncertainty), which determine the posterior probability. The Bayes estimates in the Table 1. indicate both the measures of uncertainty and also an *estimate* of the proportion of children in the population (76.5 per 1000 live births) that would eventually die who were born to less educated mothers (i.e. those mothers who were educated less than high school, the social class which we consider in this particular demonstration).

Year	**Child Mortality**(Per 1000)	**Bayes Estimates**
1992-1993	109.3	76.50
1998-1999	94.9	80.31
2005-2006	74.3	89.67

Table-1: NFHS Based Child Mortality Estimates

Figure 1. Bayesien posterior estimators of child mortality in India

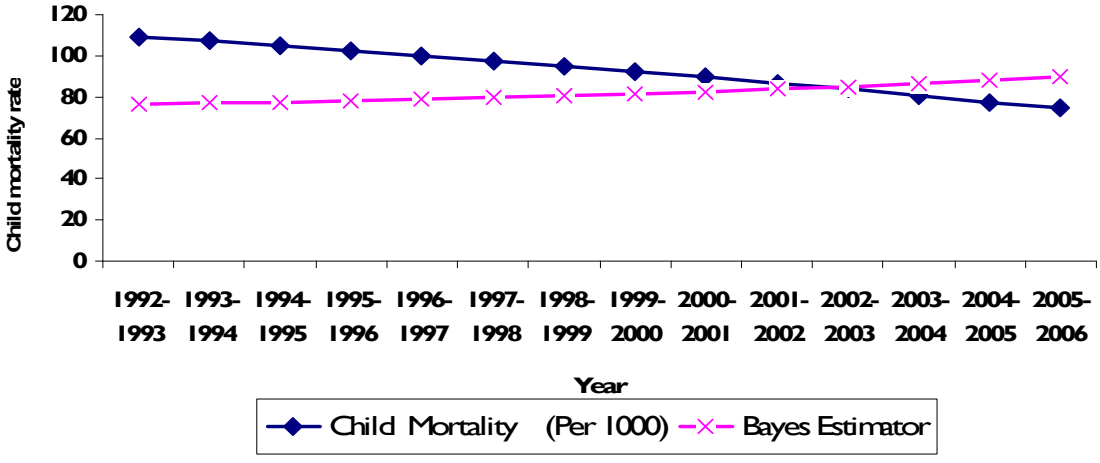


Figure2. Bayesian posterior estimators for Indian States by NFHS-I

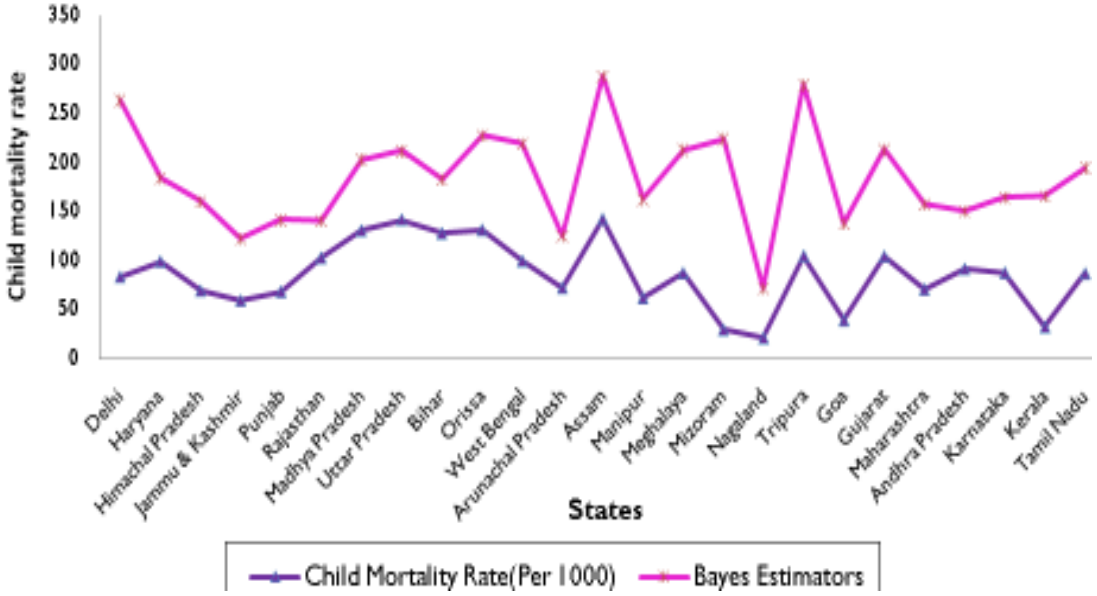
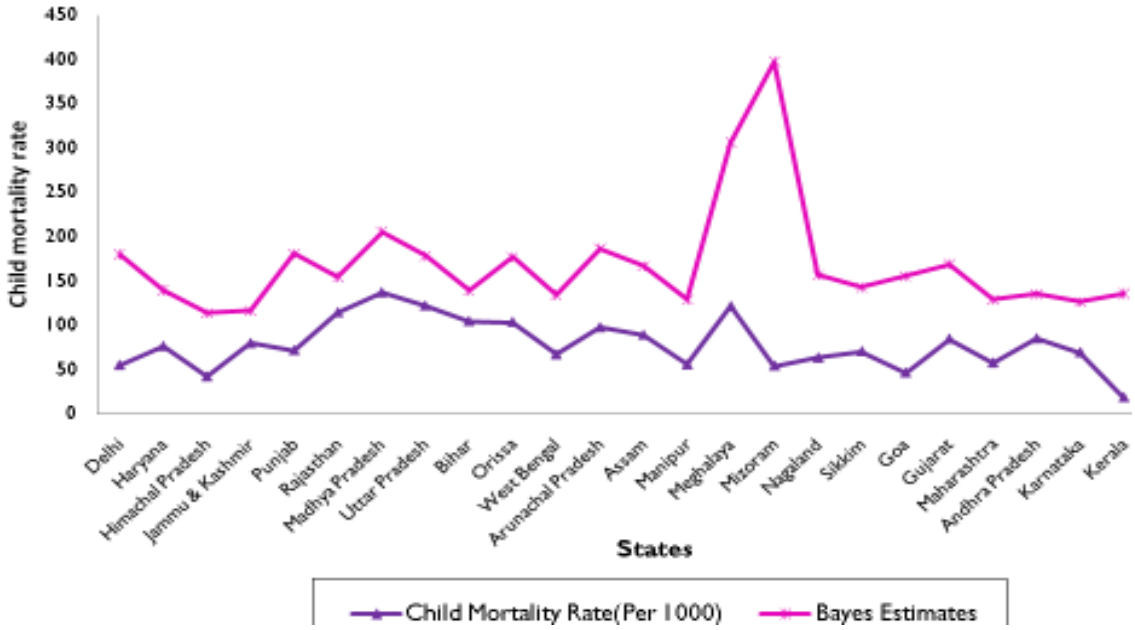
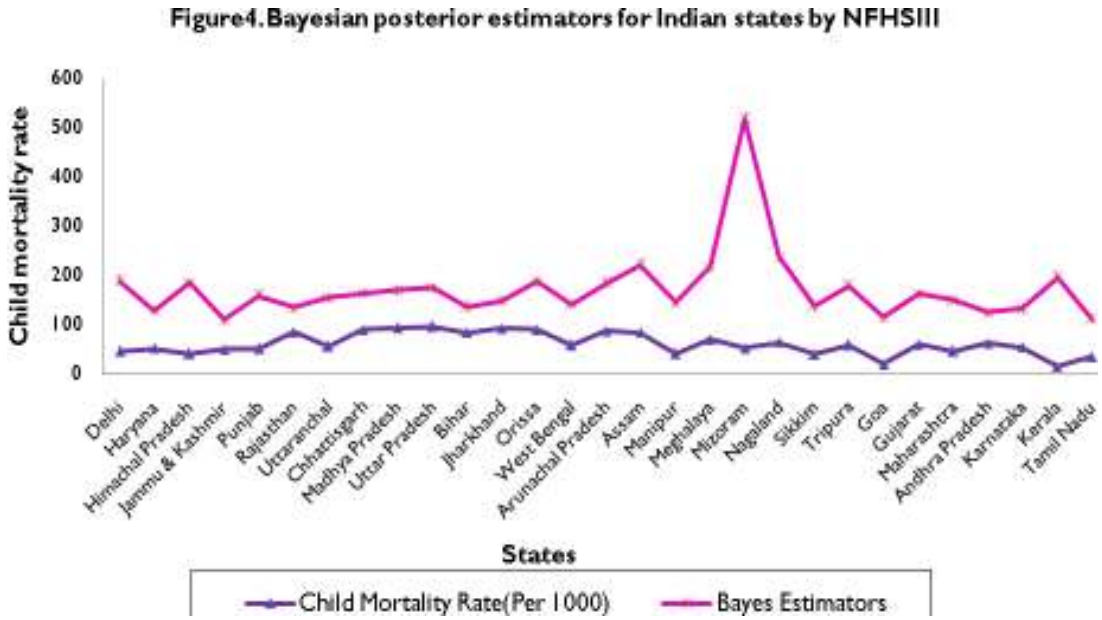


Figure3. Bayesian posterior estimators for Indian States by NFHS-II





A set of variables and corresponding Bayesian parameters will be estimated in the full version. Figure 1 gives all India trend estimated from a proper prior probabilities and Figure 2. provide posterior probabilities estimated for the major states in India based on NFHS –III. Further, we can write posterior probability that a child with a less educated mother dies as (0.551 *b*) / {0551 *b* + 0.449 (1-*b*)}, where is *b* is prior probability of child mortality.

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