Original Article:

A Bayesian Approach in 2×2 Tables: An Application in Anemia Status in Pregnant and Lactating Women in India

Atanu Bhattacharjee[1] and Dibyojyoti Bhattacharjee[2]
[1]Department of Statistics, Gauhati University, Guwahati-781014, India
[2]Department of Business Adminstration, Assam Universtiy
Correspondence to Atanu Bhattacharjee[1]: E-mail ID – atanustat@gmail.com

Abstract:

Background: India contributes towards 25 per cent of deaths in the world due to the pregnancy and related health problems. We aimed to observe the changes of level of prevalence of Anemia among lactating and pregnant women over the last decades in India.

Methods: The National Health Surveys have been conducted in India during 1998 and 2006 namely NFHS-2 and NFHS-3. A total of 1751 women have been studied by team of Healthcare & Research Association for Adolescents Noida & Nutrition Foundation of India (H. R. A. A. N & N. F.I) from seven states of India in 2004. The changes of prevalence rate of Anemia among pregnant and lactating women have been explored in this work. The Bayesian approach in the parametric model has been applied to deal with coarse data problem.

Results: The overall prevalence of Anemia in 1998, 2004 and 2006 are observed with 55 per cent, 52.44 per cent and 84.0 per cent respectively. The posterior Mean (SD) of mild, moderate and severe Anemic status among pregnant and lactating women have been found with [1.1(0.52), 0.47 (0.53), -3.9(0.24)] and [0.69(1.06), -2.69(0.21),-.25(0.83)] in 2006 with respect to 2004 study.

Conclusion: Some improvement on nutritional status has been found on pregnant women. However, no significant change of Anemia prevalence has been observed on lactating women during the last few decades in India.

Key words: Anemia, Association of Attributes, Hemoglobin, Iron-deficiency.

Background:

India is sharing one fourth of maternal death of the world[1,2]. The policy and political priority play an important role to control the factors associated with maternal health in India[3, 4]. The implementation of effective intrapartum-care strategy can be useful to improve the maternal health status in India[6]. The adequate supply of skilled health care providers and well-equipped facilities of health care are important factor to reduce the Maternal Mortality Rate (MMR) in India[7]. Several studies have concluded about the reduction rate of maternal death, the importance of family planning, safe abortion and intrapartum care in India [8, 9]. Some other studies have found the importance of several interventions for reduction of MMR in India. The poor settings of obstetric care units in hospitals is an important factor for high MMR in India.[10,11] In this connection it can be pointed out that the level of hemoglobin plays an important role to prevent the pregnancy and delivery related death. The Anemia is the most digestive disease for the malabsorption. The reason of anemia is the low level of Hemoglobin. The degree of anemia can be diagnosed based on level Hemoglobin.[12] In this context; it is an important issue to look upon the reduction of prevalence of Anemia over the period in Indian women. Taking into account the goal, the level of Anemia prevalence changes among lactating and pregnant women in the time periods 1998, 2004 and 2006 has been explored in this work. The data has been obtained from the published work of NFHS-3[15], NFHS-2[13] and H. R. A. A. N & N. F.I group study[14].

In NFHS-3[15] and NFHS-2[13] the nutritional measurements of the ever married women have been carried out by the level of hemoglobin in their blood. The Hemocue instrument has been involved to test their hemoglobin level. All ever-married women of age of 15-49 have been considered for the direct measurement of hemoglobin. The details of the procedure can be seen on the NFHS-3[15] and NFHS-2[13] manual. The levels of severity of Anemia have been categorized by (10.0-10.9 g/dl) for mild Anemia, (7.0-9.9 g/dl) for moderate Anemia and (less than 7.00 g/dl) for severe Anemia.

H. R. A. A. N & N. F.I group study[14] have carried out the cross sectional study between September 2001 and April 2003, on hemoglobin status of the women through cyan met hemoglobin methods in the states of Assam, Haryana, Himachal Pradesh, Kerala, Madhya Pradesh, Orissa and Tamil Nadu respectively. The classification of Anemia in the largest population based study is an important issue to prevent the death due to low hemoglobin[16]. The prevalence of Anemia over the period of time can be useful indicator for health status changes in India. The pregnant and lactating women's Anemia status changes have been considered in this study.

Material and Methods

The posterior mean of the mild, moderate and severe anemia status have been compared with state wise pregnant and lactating women obtained from different study reports through Bayesian approach. The comparison with classical approach has also been carried out on the prevalence data. The three sets of data have been considered to know the changes of prevalence of Anemia in Indian women during 1998, 2004 and 2006 by the representative studies of those years i.e. NFHS-2[13], H. R. A. A. N & N. F.I group study [14] and NFHS-3[15]. However, in case of NFHS-2[13], NFHS-3[15] surveys the all Indian states have been considered. But in the study of H. R. A. A. N & N. F.I group study (2004) only the states of Assam, Haryana, Himachal Pradesh, Kerala, Madhya Pradesh, Orissa and Tamil Nadu have been considered. These seven states have been considered due their available information in three studies.

Methodology for comparison

In this work, the model is

$L_i \sim$ Binomial (N_i, p_i) (1)

where, $p_i = r_{i1}x_i + r_{i2}(1 - x_i)$, (2)

The r_{i1} and r_{i2} are used to represent i^{th} state's (considered in this work) rate of Anemia among the pregnant and lactating women respectively. The proportions of women in the pregnant and lactating women are denoted by x_i and $(1-x_i)$ respectively. The terms Y_i and $(1-Y_i)$ have been used as the proportion of pregnant & lactating women of the i^{th} state. The parameter L_i has been used for the total anemic population in the i^{th} state population of N_i.

The observed value of r_{i1} and r_{i2} can be denoted by r_{i1}^* and r_{i2}^*. The logit of ri1 and ri2 have been assumed with N (0, 1) and Wishart prior for scale matrix[17]. The absolute error has been measured by

$$E_r = \Sigma_i \Sigma_j \left| r_{ij} - r_{ij}^* \right|, \quad (3)$$

The formulated table for Anemia in pregnant and lactating women is given below:-

Table1: Cross table on pregnant and non anemic women

	Anemia	**Non Anemia**	**Total Women in the i^{th} state**
Pregnant	W_{1i}	W_{2i}	Y_i
Lactating	$1-W_{1i}$	$1-W_{2i}$	$1-Y_i$
	X_i	$1-X_i$	N

where, Y_i and X_i represent the observed margins, and W_1 and W_2 are unknown variability.

Y_i is the total proportion of pregnant women in the i^{th} state; X_i is the proportion of Anemic women in the i^{th} state. The parameters W_{1i} and W_{2i} are Anemic and Non-Anemic respectively.
So, the relationship can be established by
$Y_i = X_iW_{1i} + (1-X_i)\, W_{2i}$ (4)
where, N is the size of each table.
The margin n_{rc} and n_{ic} have been extended into R*C tables[17].

Table2: The R × C count table

					Total
	n_{i11}	n_{ii2}	...	n_{i1c}	n_{i1}
	n_{i21}	n_{i22}	...	n_{i2C}	n_{i2}
	...	...	...	...	...
	n_{iR1}	n_{iR2}	...	n_{iRc}	n_{iR}
Total	$n_{i.1}$	$n_{i.2}$	...	$n_{i.c}$	N_i

where, $n_{nr.}$ and $n_{i.c}$ are the observed margins, N_i is the size for the table and n_{irc} are unknown variables.
$n_{ir.}=\Sigma_{c=1}^{C} n_{irc}$ for r = 1,2,….,R.
$n_{i.c}=\Sigma_{c=1}^{R} n_{irc}$ for c = 1,2,,,,C.
where, $\max(0, n_{ir.}+n_{i.c}-N_i) \leq n_{irc} \leq \min(n_{ir.},n_{i.c})$.

Table 3: The R×C Table has been reformulated into

W_{i11}	W_{i12}	...	W_{i1c}	Y_{i1}
W_{i21}	W_{i22}	...	W_{i2c}	Y_{i2}
...	...	...	...	...
W_{iR1}	W_{iR2}	...	W_{iRc}	Y_{iR}
$X_{i.1}$	$X_{i.2}$	...	$X_{i.c}$	N_i

where,
$Y_{ir} = \sum_{c=1}^{C} X_{ic}W_{irc}$ for r=1,2,…R. and
$Y_{ir} = \sum_{r=1}^{R} X_{ic}W_{irc}$ for c=1,2,…C.
The proportion for each table stands for,

$$\max(0, X_{ic} + Y_{ir-1})/X_{ic}) \leq W_{irc} \leq \min(1, Y_{ir}/X_{ir})$$

In this work, the proportion of Anemia pregnant, non Anemia pregnant, Anemia lactating and non Anemia lactating women have been converted to count data. The count data have been applied in the Bayesian algorithm for the state wise comparison.

Inference Problem in 2×2 Tables

For every state i=1, 2….,n to formulate the 2×2 table. The Y_i is total numbers of women, X_i for pregnant women. Where, W_{i1} and W_{i2} are applied for the proportion for pregnant women in Anemia and lactating women in Anemia respectively. The deterministic relation can be formulated by

$$Y_i = W_{i1}X_i + W_{i2}(1 - X_i) \quad (5)$$

In the above equation, the parameter X_i and $(1-X_i)$ are observed weight and W_{i1} and W_{i2} are unobserved weight.

The difficulties come to obtain distribution assumption of the unknown parameters W_{i1} and W_{i2} in the population. In addition to that the particular observation of W_{i1} and W_{i2} in each state ($i=1,\ldots, n$) is also a challenge to estimate. The inconsistent estimation of the unknown parameters W_{i1} and W_{i2} are coined by Neyman and Scott[18] with "Incidental parameter problem". Recently, it applied and solved under structure with coarse data[17,19]. The limits of W_{i1} and W_{i2} in equation (5) can be expressed as,

$$W_{i1} \epsilon [\max(0, \tfrac{X_i+Y_i-1}{X_i}), \min(1, \tfrac{Y_i}{X_i})], \quad (6)$$

$$W_{i2} \epsilon [\max(0, \tfrac{Y_i-X_i}{1-X_i}), \min(1, \tfrac{Y_i}{1-X_i})], \quad (7)$$

The likelihood function $L(\xi, \gamma|W, X)$ for the coarsening (X_i) and coarsened (Y_i) variable in the equation (5) has been considered to obtain the posterior mean estimates[17]. The likelihood function

has been obtained by the joint distribution of $f(W_i|\xi)$ and conditional distribution function of $h(X_i|W_i,\gamma)$.

It can be expressed by

$$L(\xi,\gamma|W,X) = \prod_{i=1}^{n} h(X_i|W_i,\gamma)f(W_i|\xi) \quad (8)$$

The term $f(W_i|\xi)$ is the density function of W_i with the unknown parameterξ. The part $h(X_i|W_i,\gamma)$ is the density function of X_i given W_i with the unknown parameterγ. The parameter W_i^* has been segregated by,

$$W_i^* \sim (W_{i1}^*, W_{i2}^*) = \text{logit}\big((W_{i1}), \text{logit}(W_{i2})\big), \quad (9)$$

Here, the likelihood function $L(\xi,\gamma|W,X)$ has been used to obtain the posterior estimates.

Statistical Analysis

Statistical analysis has been carried out using Winbug-14.3.1[20]. The prior distribution has been used to obtain the posterior mean value of each category in the sample. The cumulative comparative figures obtained through different states have been considered in this work. The posterior mean for Y_i states has been obtained by the combined posterior mean of the X_i, 1-X_i, W_{1i} and W_{2i} respectively. The prior information about the X_i and 1-X_i has been taken from the published work of NFHS-2[13], NFHS-3[15] and H. R. A. A. N & N. F.I group study[14]. The weights for the pregnant anemic and non-anemic women are considered with W_{1i} and W_{2i} respectively. In case of the lactating women the weight for anemic and non-anemic women are 1-W_{1i} and 1-W_{2i} respectively. It has been assumed that the weight follows the uniform distribution with mean 0 and standard deviation 1 in the prior specification. The application have been carried out separately for the pregnant women and lactating women. In this work, in order to select the sample of two independent chains of 20,000 iterations, each run has been obtained to a burn-in period of 5000 iterations to allow the normal proposal distribution to finish the adapting. The chains are appeared to converge well before the end of the burn-in period. The posterior mean for the different status of hemoglobin have been computed and tabulated in Table 4 and Table 5.

Table 4:- The comparative prevalence rate of Anemia on pregnant and lactating women in India

States	Pregnant women			Lactating Women		
	10.0-11.9	7-9.9 g/dl	≤12.0 g/dl	10.0-11.9	7-9.9 g/dl	≤12.0 g/dl
1	25.2 (25.6) (6.8)	40.6 (34.2) (72.7)	72.6 (37.7) (6.1)	26.0 (67.7) (24.8)	43.8 (8.6) (1.0)	73.3 (4.3) (29.1)
2	26.0 (20.6) (19.1)	43.1 (33.1) (63.3)	71.1 (44.5) (9)	20.6 (57.1) (20.3)	40.7 (13.4) (2.5)	63.5 (4.5) (44.9)
3	27.5 (18.3) (38.3)	12.8 (12.8) (29.8)	40.3 (68.2) (31.9)	10.0 (30.3) (10.0)	36.3 (0) (1.0)	47.9 (9.2) (52.4)
4	19.7 (11.6) (33.6)	15.5 (8.7) (21.3)	35.2 (79.7) (3.2)	4.1 (14.3) (1.1)	28.5 (0) (0.2)	32.5 (39.3) (78.7)
5	23.6 (0.9) (4.8)	33.1 (21.9) (52.8)	58.7 (46.2) (42.2)	17.2 (54.5) (14.8)	47.4 (27.3) (1.2)	58.7 (0) (42)
6	37.1 (0.7) (23.8)	29.6 (26.8) (68.3)	68.8 (39.5) (3)	16.1 (61.2) (17.9)	47.3 (3.7) (1.1)	64.9 (0.7) (35.2)
7	28.2 (25.5) (30.8)	27.7 (27.1) (57.7)	57.8 (42.9) (8.5)	9.1 (50) (19.3)	48.6 (3.4) (3.5)	57.8 (9.1) (38.4)

(Legend of Table 4 - States)
1. Assam NFHS-3[15] NFHS-2[13] H. R. A. A. N & N. F.I group study [14]
2. Haryana NFHS-3[15] NFHS-2[13] H. R. A. A. N & N. F.I group study [14]
3. Himachal Pradesh NFHS-3[15] NFHS-2[13] H. R. A. A. N & N. F.I group study
4. Kerala NFHS-3[15] NFHS-2[13] H. R. A. A. N & N. F.I group study [14]
5. Madhya Pradesh NFHS-3[15] NFHS-2[13] H. R. A. A. N & N. F.I group study [14]
6. Orissa NFHS-3[15] NFHS-2[13] H. R. A. A. N & N. F.I group study [14]
7. Tamil Nadu NFHS-3[15] NFHS-2[13] H. R. A. A. N & N. 7 F.I group study [14]

Table 5:- The comparison between NFHS-3 and H. R. A. A. N & N. F.I group study 14 and NFHS-2 through posterior mean on lactating women

NFHS-3 v/s H. R. A. A. N & N. F.I group study[14]						
	Lactation			Pregnant		
	Mean(SD)	**Median**	**HPD (97.5%, 2.5%)**	**Mean(SD)**	**Median**	**HPD (97.5%, 2.5%)**
Mild	0.69(1.06)	0.66	(2.87, -1.40)	1.10(0.52)	1.09	(2.17, 0.071)
Moderate	-2.69(0.21)	-2.69	(-2.27, -3.15)	0.47(0.53)	0.46	(1.56, -0.58)
Severe	-0.25(0.83)	-0.26	(1.44, -1.94)	-3.99(0.24)	-3.99	(-3.52, -4.49)
Any Anemia	1.84(1.26)	1.83	(4.40, -0.61)	2.78(0.44)	2.77	(3.70, 1.92)
NFHS-3 v/s NFHS-2						
Mild	2.54(0.62)	2.543	(3.80, 1.28)	-1.07(0.32)	-1.07	(-0.42, -1.72)
Moderate	1.18(0.25)	1.19	(1.66, 0.64) 0.40(0.16)	0.41	(0.71, 0.07)	
Severe	5.44(0.45)	5.42	(6.38, 4.59) -2.72(0.27)	-2.71	(-2.20, -3.28)	

Table 6:- The comparison between NFHS-3 and H. R. A. A. N & N. F.I group study[14] and NFHS-2 through posterior mean on pregnant women

NFHS-3 v/s H. R. A. A. N & N. F.I group study[14]			
Type of Anemia	**Mean**	**Median**	**97.5%**
Mild	**1.10(0.52)**	**1.09**	**(2.17, 0.071)**
Moderate	**0.47(0.53)**	**0.46**	**(1.56, -0.58)**
Severe	**-3.99(0.24)**	**-3.99**	**(-3.52, -4.49)**
Any Anemia	**2.78(0.44)**	**2.77**	**(3.70, 1.92)**
NFHS-3 v/s NFHS-2			
Mild	**-1.07(0.32)**	**-1.07**	**(-0.42, -1.72)**
Moderate	**0.40(0.16)**	**0.41**	**(0.71, 0.07)**
Severe	**-2.72(0.27)**	**-2.71**	**(-2.20, -3.28)**
Any Anemia	**4.34(0.39)**	**4.33**	**(5.16, 3.60)**

Results:

The state wise calculated posterior mean are given in the Table 4 and Table 5. The Highest Posterior Density (HPD) has been used for the estimated posterior mean with 95% credible interval. In NFHS-3[15] vs. H. R. A. A. N & N. F.I group study [14] for lactating women, the posterior mean (HPD interval) for mild, moderate, severe and any Anemia are found to be 0.69 (2.87,-1.4), -2.69(-2.27,-3.15), -0.25 (.44, -1.94) and 1.84 (4.40, -0.61) respectively. It confirms that the prevalence of mild and any type of Anemia increased in NFHS-3 duration in comparison to study year 2004. Whereas, in the same periods the moderate and severe types of Anemia reduced by posterior mean -2.69 and -0.25 respectively.

In case of NFHS-2 v/s NFHS-3, the posterior mean (HPD interval) for mild, moderate, severe and any Anemia are 1.03(1.85, 0.19), 2.54(3.80, 1.28), 1.18(1.66, 0.64) and 5.44(6.38, 4.59) for the lactating women. The results of pregnant and lactating women's prevalence of Anemia are given in Table 4. In case of pregnant women NFHS-3[15] vs. H. R. A. A. N & N. F.I group study[14], the two chain of posterior means (Highest Posterior Density) has been completed by mild and moderate at 1.10(2.17, 0.071), 0.47(1.56, -0.58) with a 95% HPD interval on severe Anemia value by -3.99(-3.52, -4.49). The computed posterior mean of NFHS-2[13] versus NFHS-3[15] are mild and moderate have the value -1.07(-0.42, -1.72) and 0.40(0.71, 0.07) respectively. It can be concluded that the significant progress to the way of reduction of Anemia have been found in both stages women (i) lactating women and (ii) pregnant women.

Discussion:

The WHO has defined the Anemia as lower level of haemoglobin for women (12g/dL) and men (13g/dL). A total of 24.8% populations in the world are affected by iron deficiency or anaemia[21]. A total of 164 million people are affected by Anemia in the world[28]. In spite of increasing prevalence rate it is one of the neglected nutritional disorder diseases in India[22]. Over several years, anemia appeared to be important risk factor for variety of adverse outcome disorder[23-26]. The effective monitoring and implementation of evidence-based strategies on anemic level can reduce the MMR[27]. The Anemia is significantly associated with smoking habit, low body mass index, renal insufficiency and diabetes[29]. The presence of Anemia can be a relevant effect on healthcare needs and increase the burden of health services[30-31]. The mild Anemia is strongly associated with worse cognitive with quality of life[32]. The reason behind high hospitalization rate and mortality is due to the presence of mild Anemia in older women[33]. The anemia is highly prevalent in adolescent girls[43]. The poor foetal occurs due to presence of iron deficiency in pregnancy[44]. The failure of nutritional anemia-control programme in India can be overcome by making an impact on the outcome of pregnancy through iron supplementation[45]. The risk of having Anemia is higher in women than men[46]. WHO has confirmed the failure in restoring iron status in women may increase the maternal mortality and child death in the world[47].

The anemia is positively associated with mortality[34-38]. The main constraint of the literature of anemia is that the inception and conclusion are not well documented. The chronic immune activation and inflammation can also be a cause of anemia in addition of nutrition deficiency[39] .The creation of erythropoietin due to presence of chronic kidney disease can be a reason for anemia[40]. There are some other reasons also for anemia called as "unexplained anemia" [40-42]. From various studies and reports it can be stated that the risk of having Anemia is higher in women and the presences of it can be the results of maternal mortality and birth of low weight baby.

In NFHS-2[13], the prevalence of Anemia has been found high in breast feeding and lactating women. H. R. A. A. N & N. F.I group study[14] have compared the results with NFHS-2[13] report. It has been found that the higher prevalence of Anemia in H. R. A. A. N & N. F.I group study[14] for pregnant and lactating women study as compared to the NFHS-2[13] report. In NFHS-3[15], the prevalence of Anemia has been found higher in the breast feeding women than lactating women. It also confirmed that the provision of iron and folic acid supplement successfully reduced the prevalence of Anemia among pregnant women. In this work, we have compared the three results (i.e. NFHS-3[15], NFHS-2[13] and H. R. A. A. N & N. F.I group study[14] through Bayesian approach. The results have been compared by the posterior mean with Highest

Posterior Interval. From the results, it can be confirmed that the output for the lactating women are same in case of NFHS-2[13] and NFHS-3[15] report. Whereas, the more similarity between NFHS-3[15] and H. R. A. A. N & N. F.I group study[14], has been found for the pregnant women in comparison to lactating. In our view, the requirement of iron is also important during the lactating period of the women.

Conclusion:

The anemia can occur due to presence of several factors. The leading factor is nutrition deficiency. A larger effort is needed to better observe the onset of anemia and categorize the reason behind it. The trace is required to overcome the nutritional disorder specially the iron deficiency in Indian women. In this article, the Bayesian approach is used in the 2×2 tables. The unknown distributional assumption of the parameter of interest in the density function has been dealt with the prior assumption. The work is involved to compare the state wise hemoglobin status of the pregnant and lactating mothers. The future health of India will be determined by our child's today. So, the reduction of Anemia prevalence among children is also an important issue. The work can also be extended to compare the Anemia status of children in this context. This study on this issue can be useful for policy maker for future goal of our country. The other outcomes of interest can also be taken care. It can be confirmed that, the state of Orissa, the moderate level of Anemia among pregnant women was reported highest in NFHS-3. In NFHS-2, the state of Assam has been reported with highest numbers of moderate Anemia among pregnant women followed by Tamil Nadu. The reports of NFHS-3[15] and NFHS-2[13] say that, among the lactating women the highest moderate anemic women belong to the state of Tamilnadu and MP. The comparison with Bayesian approach opens another dimension. It suggests that the moderate level of Anemia in the lactating women has been reduced in NFHS-3[15] study period in comparison to the study period of 2004 conducted by Agarwal et al. (2004). However, the prevalence of severe level Anemia has been reduced in NFHS-3[15] study period in comparison to H. R. A. A. N & N. F.I group study[14] study. It can also be confirmed that the illustrated method is very much straightforward to apply in other problems.

Reference:

1. World Health Organization (WHO) Maternal mortality in 2005: estimates developed by WHO, UNICEF, UNFPA, and The World Bank. Available: http://www.who.int/whosis/mme_2005.pdf. Accessed 19 August 2009.
2. Hill K, Thomas K, AbouZahr C, Walker N, Say L, et al. Estimates of maternal mortality worldwide between 1990 and 2005: an assessment of available data. Lancet 2007; 370: 1311–1319.
3. Shiffman J, Ved R. The state of political priority for safe motherhood in India. BJOG 2007; 114: 785–90.
4. Shiffman J.Generating political priority for maternal mortality reduction in 5 developing countries. Am J Public Health 2007; 97: 796–803.
5. Campbell OM, Graham WJ, Lancet Maternal Survival Series steering group .Strategies for reducing maternal mortality: getting on with what works. Lancet 2006 Oct 7; 368(9543):1284-99.
6. Costello A, Azad K, Barnett S. An alternative strategy to reduce maternal mortality. Lancet 2006; 368: 1477–1479.
7. Taghreed A,Stephen S L, Sumi M,Zulfiqar A B, Helga F, Matthews M, Jelka Z,Gary L D.Cost effectiveness analysis of strategies for maternal and neonatal health in developing ountries.2005; BMJ 331: 1107.
8. Sutherland T, Bishai D.Cost-effectiveness of misoprostol and prenatal iron supplementation as maternal mortality interventions in home births in rural India.2009; Int J Gynaecol Obstet 104: 189–193.
9. Mills S, Bos E, Lule E, Ramana GNV, Bulatao R. Obstetric care in poor settings in Ghana, India, and Kenya. 2007; Washington (D.C.): The World Bank. Available: http://www-wds.worldbank.org/servlet/main?menuPK=64187510&pagePK=64193027&piPK=64187937&theSitePK=523679&entityID=000310607_20080123112201.
10. Registrar General, India. Maternal mortality in India: 1997–2003; trends, causes and risk factors.2006; New Delhi, India. Available: http://www.mp. gov.in/health/Maternal_Mortality_in_India_1997-2003.pdf. Accessed 22 August 2009.
11. Fernando F B, Helena M and Montserrat F. A short review of malabsorption and anemia .2009; World J Gastroenterol. October 7; 15(37): 4644–4652.
12. World Health Organization (WHO) (2005) Millennium Development Goals and Health–India. Chapter III: Goal 5: improve maternal health. Geneva: WHO. Available: http://www.whoindia.org/LinkFiles/MDG_Chapter-03.pdf. Accessed 31 July 2009.

13. National Family Health Survey-2, 1998-99, India , International Institute for Population Sciences,2000; VOLUME I.
14. Agarwal K.N., Agarwal D.K., Sharma A., Sharma K., Prasad K., Kalita M.C., Khetarpaul N,Kapoor A.C., Vijayalekshmi L., Govilla A.K., Panda S.M. and Kumari P. Prevalence of anaemia in pregnant & lactating women in India Healthcare & Research Association for Adolescents Noida, & Nutrition Foundation of India,India. Indian J Med Res 2006;124, pp 173-184.
15. National Family Health Survey-3, 2005–06, India , International Institute for Population Sciences,2007; VOLUME I.
16. Mauro Tettamanti, Ugo Lucca, Francesca Gandini, Angela Recchia and et al. "Prevalence, incidence and types of mild anemia in the elderly: the "Health and Anemia" population-based study" Haematologica. 2010; November; 95(11): 1849–1856.
17. Kosuke Imai,Ying Lu,Aaron Strauss.Bayesian and Likelihood Inference for 2 *3* 2 Ecological Tables: An Incomplete-Data Approach. 2008; Political Analysis 16:41–69.
18. Neyman, J., and E. L. Scott. Consistent estimation from partially consistent observations. 1948; Econometrica 16:1–32.
19. Gary King: A Solution to the Ecological Inference Problem: Reconstructing Individual Behavior from Aggregate Data.1997; Princeton University Press, New Jersey.(The Software can be freely downloadedfrom www.mrcbsu.cam.ac.uk/bugs/**winbugs**/contents.shtml*).*
20. WHO (2008) worldwide prevalence of anaemia 1993–2005. In: de Benoist B, McLean E, Egli I, Cogswell M, editors. WHO global database on anaemia. Geneva: World Health Organization.
21. Gopalan C (1992) Strategies for combating under nutrition: lessons learned for the future. In: Nutrition in developmental transition in Southeast Asia. New Delhi: World Health Organization. pp 109–111.
22. Culleton BF, Manns BJ, Zhang J, Tonelli M, Klarenbach S, Hemmelgarn BR. Impact of anemia on hospitalization and mortality in older adults. Blood 2006; 107:3841–3846.
23. Denny SD, Kuchibhatla MN, Cohen HJ. Impact of anemia on mortality, cognition, and function in community-dwelling elderly. Am J Med 2006; 119:327–334.
24. Izaks GJ, Westendorp RG, Knook DL. The definition of anemia in older persons. JAMA 1999; 281:1714–1717.
25. Patel KV, Harris TB, Faulhaber M, Angleman SB, Connelly J, Bauer DC, et al. Racial variation in the relationship of anemia with mortality and mobility disability among older adults. Blood 2007; 109:4663–4670.
26. Dileep V. Mavalankar, Kranti S. Vora, K.V. Ramani, Parvathy Raman,Bharati Sharma, and Mudita Upadhyaya. Maternal Health in Gujarat, India: A Case Study J HEALTH POPUL NUTR 2009 Apr; 27(2):235-248.
27. De Benoist B, McLean E, Egli I, Cogswell M, editors. Worldwide prevalence of anaemia 1993-2005.2008; WHO Global database on anaemia. World Health Organization.
28. Mauro Tettamanti, Ugo Lucca, Francesca Gandini, Angela Recchia, Paola Mosconi, Giovanni Apolone, Alessandro Nobili, Maria Vittoria Tallone, Paolo Detoma, Adriano Giacomin, Mario Clerico, Patrizia Tempia, Luigi Savoia, Gilberto Fasolo, Luisa Ponchio, Matteo G. Della Porta, and Emma Riva. Prevalence, incidence and types of mild anemia in the elderly: the "Health and Anemia" population-based study *Haematologica 2010;95(11):1849-1856.*
29. Ershler WB, Chen K, Reyes EB, Dubois R. Economic burden of patients with anemia in selected diseases. Value Health. 2005;8 (6):629-38.
30. Robinson B. Cost of anemia in the elderly. J Am Geriatr Soc. 2003;51(3suppl):S14-S7.
31. Lucca U, Tettamanti M, Mosconi P, Apolone G, Gandini F, Nobili, et al Association of mild anemia with cognitive, functional, mood and quality of life outcomes in the elderly: the "Health and Anemia" study. PloS ONE. 2008;3(4):e1920.
32. Riva E, Tettamanti M, Mosconi P, Apolone G, Gandini F, Nobili A, et al. Association of mild anemia with hospitalization and mortality in the elderly: the Health and Anemia population-based study. Haematologica. 2009;94(1);22-8
33. Denny SD, Kuchibhatla MN, Cohen HJ. Impact of anemia on mortality, cognition, and function in community-dwelling elderly. Am J Med 2006;119:327–334.
34. Izaks GJ, Westendorp RG, Knook DL. The definition of anemia in older persons. JAMA 1999; 281:1714–1717.
35. Patel KV, Harris TB, Faulhaber M, Angleman SB, Connelly J, Bauer DC, et al. Racial variation in the relationship of anemia with mortality and mobility disability among older adults. Blood 2007; 109:4663–4670.
36. Penninx BW, Pahor M, Woodman RC, Guralnik JM. Anemia in old age is associated with increased mortality and hospitalization. J Gerontol A Biol Sci Med Sci 2006;61:474–479.
37. Zakai NA, Katz R, Hirsch C, Shlipak MG, Chaves PH, Newman AB, et al. A prospective study of anemia status, hemoglobin concentration, and mortality in an elderly cohort: the Cardiovascular Health Study. Arch Intern Med 2005; 165:2214–2220.
38. Weiss G, Goodnough LT. Anemia of chronic disease. N Engl J Med 2005;352:1011–1023.
39. Guralnik JM, Eisenstaedt RS, Ferrucci L, Klein HG, Woodman RC. Prevalence of anemia in

persons 65 years and older in the United States: evidence for a high rate of unexplained anemia. Blood 2004;104:2263–2268.
40. Ferrucci L, Guralnik JM, Bandinelli S, Semba RD, Lauretani F, Corsi A, et al. Unexplained anaemia in older persons is characterised by low erythropoietin and low levels of pro-inflammatory markers. Br J Haematol 2007;136:849–855.
41. Artz AS, Fergusson D, Drinka PJ, Gerald M, Bidenbender R, Lechich A, et al. Mechanisms of unexplained anemia in the nursing home. J Am Geriatr Soc 2004;52:423–427.
42. Toteja GS, Singh P, Dhillon BS, Saxena BN, Ahmed FU, Singh RP et al. Prevalence of anemia among pregnant women and adolescent girls in 16 districts of India. Food Nutr Bull 2006;27:311-5.
43. Beard JL, Dawson H, Pinero D. Iron metabolism: a comprehensive review. Nutr Rev.1996;54:295–317.
44. Kumar A. National nutritional anaemia control programme in India. Indian J Public Health.1999;43:3–5.
45. Sharma JB: Nutritional anaemia during pregnancy in non-industrialised countries. In Progress in Obstetrics and Gynaecology. Edited by: Studd J. Edinburgh Churchill Livingstone; 2003:103-122.
46. World Health Organization. Iron deficiency anaemia: assessment, prevention, and ontrol: a guide for programme managers. Geneva: World Health Organization, 2001. 132 p. (WHO/NHD/01.3).

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