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Nutrient Intake Adequacy and Dietary Gaps Among Pregnant Women in the Madhepura District of Bihar: A Cross-sectional Study

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Abstract

Objective: The objective of the study was to quantify the nutrient intake of pregnant women in their second trimester, compare the mean nutrient intake with the estimated average requirement. We aimed to arrive at the NAR, MAR and the factors influencing the MAR.

Methods: It was a longitudinal cross-sectional study done during the period of January 2023 to March 2025. Two-day dietary information was taken using the 24 hr dietary recall method. Intakes were converted to nutrients using the diet cal software. Dietary indicators such as NAR and MAR were calculated. Using the r studio student's T test, multiple linear regression and data visualization was done.

Results: The data of 400 pregnant women was assessed. The median intake of energy was 1961.1 Kcal/day, protein was 56.747 g/day, fat was 48.33g/day, thiamine was 1.151 mg/day, riboflavin was 0.609mg/day, niacin was 11.427 mg/day, pyridoxine was 1.370 mg/day, folate was 181.879 mg/day, vitamin C was 44.268 mg/day, vitamin A was 104.850 µg/day, calcium was 335.831 mg/day, magnesium was 351.102 mg/day, phosphorous was 1154.1mg/day, iron was 12.807 mg/day and zinc was 8.689 mg/day. The median energy provided by carbohydrate, fat and protein was 65%, 20% and 12 % respectively. The NAR for macromolecules was around 0.9, B-vitamin ranged from 0.271 to 0.717. The most deficit B-vitamin was riboflavin which was deficit in all the pregnant women and folic acid which was deficit in 98% of the pregnant women with NAR of 0.439. Vitamin A was deficit in 99.5% of the pregnant women with NAR of 0.266. Calcium and iron were the most limiting mineral with mean NAR of 0.456 and 0.637 respectively. The MAR of the diet was 0.719. Mean intake of all nutrients differed significantly (p-value<0.001) except for energy and magnesium. Socioeconomic status and family structure (p-value<0.001) influences the mean adequacy ratio.

Conclusion: This is the only study that has quantified the nutrient in the diet of pregnant women of Madhepura, Bihar. The diet of pregnant women is deficit in vitamins particularly riboflavin, folate, ascorbate, vitamin A and mineral namely calcium, iron and zinc. There is a need of dietary fortification, counselling, millets, green vegetables and citrus fruits should be provided by aanganwadi and monitoring of IFA tablet consumption by the ASHA.

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Keywords: NAR (Nutrient adequacy ratio), MAR (mean adequacy ratio), BMI (Body mass Index)

Introduction: Pregnancy is a critical period characterized by rapid physiological, hormonal, and metabolic changes to support foetal growth and maternal health. Adequate nutrient intake is essential to ensure optimal outcomes for both the mother and the baby. Poor maternal nutrition can lead to complications such as intrauterine growth restriction (IUGR), low birth weight, preterm delivery, and increased maternal morbidity. What a woman eats when she is pregnant can have a profound and lasting effect on her health and the health of her child. The fetus evolves from a single-celled, fertilized egg to a neonate in only 9 months. Meanwhile, the mother must undergo her own sequence of dramatic physiologic changes. The effects of inadequate or excess intake of nutrients may be observed in the short and long terms, and it is believed that the foetal environment causes epigenetic modifications that affect gene expression and influence the development of disease[1] (Fernando et al., 2023). Therefore, for the foetus to begin and continue a healthy life, all necessary nutrients must be available in the proper quantities at the exact times they are needed.

The dietary reference intakes for Indians are given by the Indian council of medical research. The Estimated average requirement (EAR) is the nutrient requirement used in public health nutrition, to evaluate the nutrient intakes of a population. Recommended Dietary Allowance (RDA) is the average daily level of intake sufficient to meet the nutrient requirements of nearly all (97%–98%) healthy people. With RDA there is a risk of excess intake, since each individual may not require that much nutrients. In addition, nutrients can also be toxic when ingested at very high doses. The advisory committee for the nutrient requirements has also given tolerable upper limits (TUL) for nutrients[2].

The objective of the study was to document the nutrient intake of pregnant women seeking medical care from government and private facilities in Madhepura, Bihar.

Materials and Methods: This was a part of ongoing longitudinal study conducted from January 2023 to March 2025. The research was reviewed and cleared by the Departmental Research Committee, University Department of Home Science, BNMU, Madhepura.

Sample Selection: Pregnant women (n=400) in their second trimester (≥4months) seeking antenatal care from government or private health facilities in Madhepura, Bihar were included. Pregnant women consuming tobacco or alcohol and complications such as gestational diabetes mellitus, hypertension, preeclampsia etc were not included in the study.

Tools and techniques

General Profile:

Information on family type, income education and occupation of the husband was elicited using a questionnaire.

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Diet Recalls:

Information regarding the commonly consumed food items and preparations and their portion sizes was gathered using the 24-hour dietary recall method. The diet recalls were conducted face-to-face on two non-consecutive week days and care was taken to avoid Sunday, feasting and fasting days.

Estimation of Food Portion Size: While collecting the dietary information using the 24 hr dietary recall method, the respondents were shown different sizes of Katori in order to estimate the amount of food consumed by the respondents. These were then converted into raw ingredient weight and the Diet-cal software was used to calculate the nutrient intake of the pregnant women.

Calculation of nutrient-based indexes: Nutrient Adequacy Ratio (NAR) and **Mean Adequacy Ratio (MAR)** are widely used dietary quality indicators applied in nutritional epidemiology to assess how well an individual's or a population's diet meets recommended nutrient intakes. Nutrient adequacy ratio is usually capped at 1 to avoid overconsumption of one nutrient compensating for inadequacy of another. ICMR recommends EAR for comparing the nutrient adequacy ratio, to define if any inadequacy exists.

$$Nutrient\ Adequacy\ Ratio = Observed\ Intake \div Estimated\ Average\ Requirement$$

NAR < 1 → inadequate intake of that nutrient
NAR = 1 → adequate intake

Mean adequacy ratio is an index that quantifies the overall adequacy of an individual's diet in terms of multiple nutrients. It is calculated by first computing for each selected nutrient the Nutrient Adequacy Ratio (NAR) and the dividing it with the number of nutrients. The MAR is the arithmetic mean of those truncated NAR values across all selected nutrients, yielding a value on a scale from 0 to 1 (or 0 % to 100 %) in which 1 (or 100 %) indicates that for every nutrient in the index the intake met or exceeded the recommendation (index)[3].

Statistical Analysis: Student T test was done to compare the intake mean with the recommended mean, Multivariate regression was done to study the factors affecting the mean adequacy ratio. All the statistical analysis and visualisation was done using the r studio.

Result and Discussion: Table no. 1 presents the general profile and characteristics of the participants. Mean age of marriage was 19.773 (2.862) years, mean age of conception was 23.493 (4.493) years. Median gravid was 1 meaning majority of the pregnant women were conceiving for the second time. Median pre-conceptional BMI was 20.670 kg/m2 and median MUAC during the second trimester of pregnancy was 26 cms. Majority of the pregnant women were literate and only 10% of the pregnant women were illiterate. Occupation and income of the husband influence the socio-economic status of the family; 35.75% of the male member worked as labourer followed by agriculture and business. Majority of the pregnant women in our study were poor with 59.25% of the family having monthly income between Rs. 6175 – Rs. 18496 per

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month, 29.25% of the family had their income between Rs. 18497-Rs. 30830, only 1.25% of the family had their monthly income between Rs. 46129 – Rs 123321 per month.

Nutrient intake among pregnant women: Table no. 2 presents the dietary intake of the pregnant women. The median energy intake was 1961.1Kcal/day, protein intake was 56.747g/day, fat intake was 48.330 g/day, carbohydrate intake was 325.355 g/day, thiamine intake was 1.151 mg/day, riboflavin intake was 0.609, niacin intake was 11.427 mg/day, pyridoxine intake was 1.370 mg/day, folate intake was 181.879 mg/day, vitamin C intake was 44.268 mg/day, retinol intake was 104.850µg/day, calcium intake was 335.831 mg/day, magnesium intake was 351.102 mg/day, phosphorous intake was 1154.1 mg/day, iron intake was 12.807 mg/day and zinc intake was 8.689 mg/day. Median percentage energy obtained from carbohydrate was 64.747%, percentage energy obtained from fat was 19.860% and energy obtained from protein was 11.216 %.

Nutrient adequacy ratio was calculated against the EAR. Nutrient adequacy ratio of protein, carbohydrate and fat was very close to 1 except protein which was 0.898 with 42.75% of pregnant failed to meet the EAR (Fig.1). Among the B vitamin the most deficit was riboflavin and folic acid (Fig.2). Nutrient adequacy ratio for riboflavin was 0.271 with none of the pregnant women met the EAR and the NAR for folate was 0.439 with 98% of the pregnant women did not meet the EAR. Mean NAR for vitamin C was 0.682 and 76% of the pregnant women failed to meet the EAR. Ninety-nine-point five percent of the pregnant women failed to meet the EAR for vitamin A, NAR was 0.266. Among minerals the most deficit was calcium and iron with NAR of 0.456 and 0.637 respectively and 96% and 92.25% pregnant women diet did not meet the EAR for calcium and iron respectively. The MAR in our study was 0.719.

Student's t test was applied to see if the mean intake was same as the estimated average requirement or it differed significantly with the recommendations (table 3). Mean intake of protein, carbohydrate, niacin and phosphorous were significantly higher when compared to the EAR., 2020 whereas the mean intake of thiamine, riboflavin, pyridoxine, folate, ascorbate, retinol, calcium, iron and zinc were significantly below the EAR., 2020. The mean intake of energy was below the EAR but was not significant (p-value = 0.097) and mean intake of magnesium showed positive and not significant difference with the EAR., 2020.

Factors influencing the MAR of the diet: We used multiple linear regression to study the effect of independent variables such as age of conception, socio-economic status, family structure, caste, education and religion on the MAR. SES status and family structure significantly influences the mean adequacy ratio. With increase in socio-economic status there is an increase in the mean adequacy ratio of the diet. Pregnant women staying in a joint family had better MAR, this may be due to the work division among the female members. Quality of diet increases with increase in the socio-economic status. We calculated the SES using the Kuppuswamy Socioeconomic status scale which is based on three variables namely the education of the head of the family, occupation of the head of the family and the total monthly family income (table 4).

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Discussion: This is the only study conducted in Madhepura, Bihar which comprehensively assessed the intake of 16 nutrients namely energy, protein, fat, carbohydrate, thiamine, riboflavin, niacin, pyridoxine, folate, vitamin C, vitamin A, calcium, magnesium, phosphorous, iron and zinc in the diet of pregnant women. More than half (53%) of the women in our study consumed low amounts of energy and 42.75% consumed less protein in comparison with the EAR. Forty six percent of the pregnant women exceeded the percent energy from carbohydrate, 3.75% of the pregnant women obtained more energy from fat and 23.25% of the pregnant women achieved more percent energy from protein. The diet of the pregnant women lacked most of the micronutrients, especially thiamine, riboflavin, folate, iron, calcium and zinc.

Our results on nutrient intake are in line with previous studies on macro- and micronutrient intake and deficiencies from India and other South Asian countries[4,5,6]. The food consumption pattern is mainly cereal based and the rural pregnant women diet lacked iron, calcium, vitamin C, vitamin A, folic acid and zinc; only 52% and 60% of the pregnant women consumed adequate amount of protein and energy when compared to the RDA at national level[7]. Median energy intake was 1961.1 kcal/day, slightly below the EAR, though not significantly so ($p = 0.097$), pointing to possible marginal undernutrition. Macronutrient distribution showed carbohydrate, protein, and fat contributing 64.7%, 11.2%, and 19.9% of energy, respectively—generally within recommended ranges[8]. However, the nutrient adequacy ratio (NAR) for protein (0.90) revealed 42.7% of women below the EAR, echoing findings from Kavle et al. (2019)[9] and Ghosh et al. (2021)[10], who noted similar inadequacies due to limited animal-source foods in traditional diets. The median energy intake among pregnant women in India ranged from 1281 Kcal/day to 2051.5 Kcal/day[11,12,13,14].

Status of pregnant women in our study was below the national figure. Studies from different states of India have shown that the carbohydrate intake ranged from 179 g to 350g. Mean thiamine intake ranged from 0.46 mg to 1.6 mg. Thiamine intake in our study was close to the findings of Bellows et al., 2020[12] on the lactovegetarian and non-vegetarian pregnant women from Uttar Pradesh. Riboflavin was the most deficit vitamin in our study and riboflavin intake of 0.609 was similar to the findings of Bellows et al., 2020[12] and Deshpande et al., 2024[15]. Of all B vitamins median niacin met the EAR[12]. Deficiencies in B-vitamins, particularly riboflavin (NAR 0.27, 0% meeting EAR) and folate (NAR 0.44, 98% below EAR), were prominent. These point to diet low in dairy, eggs, and leafy greens, a pattern previously reported in South Indian populations[16]. Folate inadequacy warrants concern given its well-established role in fetal neurodevelopment[17]. Intakes of essential micronutrients such as iron, vitamin A, riboflavin, vitamin C, and folic acid were less than 50% of RDA among most pregnant women (~50–80%)[17]. Intakes of vitamin C (NAR 0.68, 76% below EAR) and vitamin A (NAR 0.27, 99.5% below EAR) were also markedly suboptimal, reflecting low consumption of fruits, vegetables, and dairy products. Widespread vitamin A deficiency has been corroborated by NFHS-5 and recent reviews [18,19]. The most substantial mineral gaps were for calcium (NAR 0.46, 96% below EAR) and iron (NAR 0.64, 92.3% below EAR), consistent with national survey data. Calcium deficiency, in particular, is a risk factor for low bone mass and adverse pregnancy outcomes, while iron deficit may lead to anemia and related complications[17,19]. The overall mean adequacy

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ratio (MAR) of 0.72 indicates that diet of the study population is moderately adequate but frequently fail to meet multiple nutrient requirements essential for maternal and foetal health.
Regression analysis identified socio-economic status (SES) and family structure as significant predictors of dietary quality. Improved SES positively influenced MAR, suggesting that financial resources, education, and occupation increase access to diverse, nutrient-rich foods [10]. Pregnant women in joint families had better MAR, likely reflecting collective support, food sharing, and traditional resource pooling, as noted in the Indian context[9]. SES assessment used the Kuppuswamy scale, integrating education, occupation, and income into stratified scores.

Conclusion:

These findings emphasize persistent dietary inadequacy during pregnancy among women, with pronounced risks for micronutrient deficiencies. There is an urgent need to prioritize maternal nutrition programs, promote diet diversification, expand fortification efforts, and deliver context-sensitive nutrition education, especially for the most socially and economically vulnerable groups in Madhepura, Bihar.

Table 1: Characteristics of Study participants

Characteristics	Mean	Median
Age of Marriage	19.773 (2.862)	19
Age of Conception	23.493 (4.468)	22
Gravida	0.880 (0.976)	1
Pre-conception BMI	21.563 (4.336)	20.670
Hemoglobin	9.538 (1.292)	9.930
Mid-upper arm circumference	26.641 (3.685)	26
Participant educational attainment (%)		
Illiterate	10	
Primary School	5	
Middle school	14.5	
High School	14.25	
Intermediate	32.5	
Graduate	16.75	
Honours/Post Graduate	6	
Occupation of the husband (%)		
Agriculture	23.25	
Carpenter	6.5	
Clerk	1.5	
Labour	35.75	
Machine operator	3	
Professional	3.75	
Shop owner	19.75	
Technician	6.5	
Income (%)		

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≤6174	2.25
6175-18496	59.25
18497-30830	29.25
30831-46128	7.5
46129-61662	1.25
61663-123321	0.5
≥ 123322	0

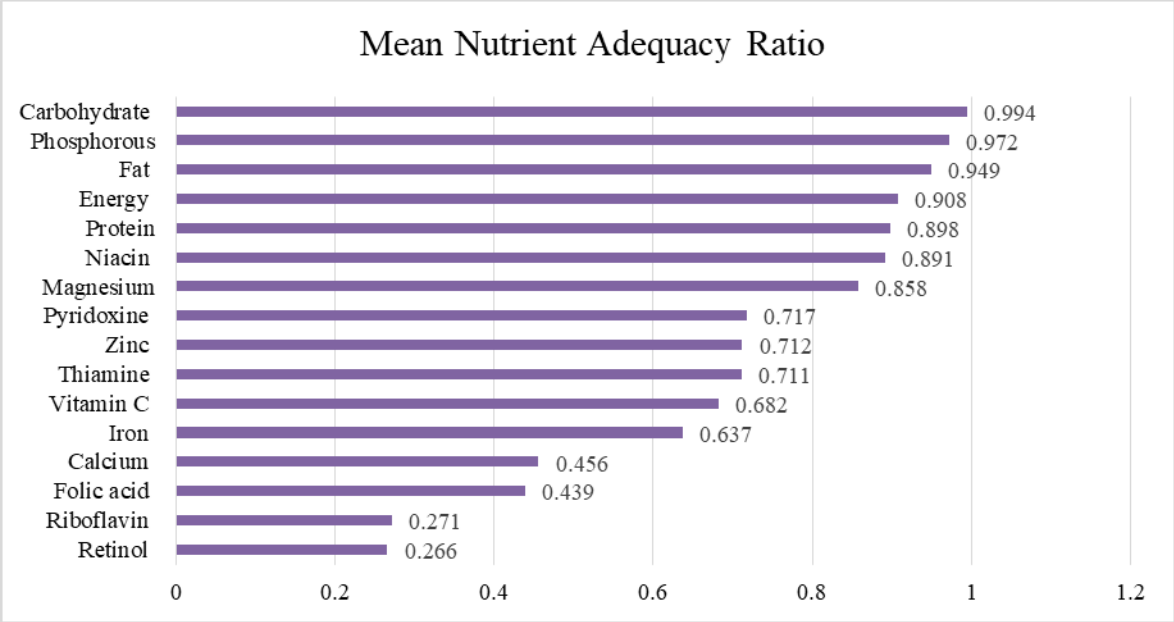

Fig1. Nutrient Adequacy Rati

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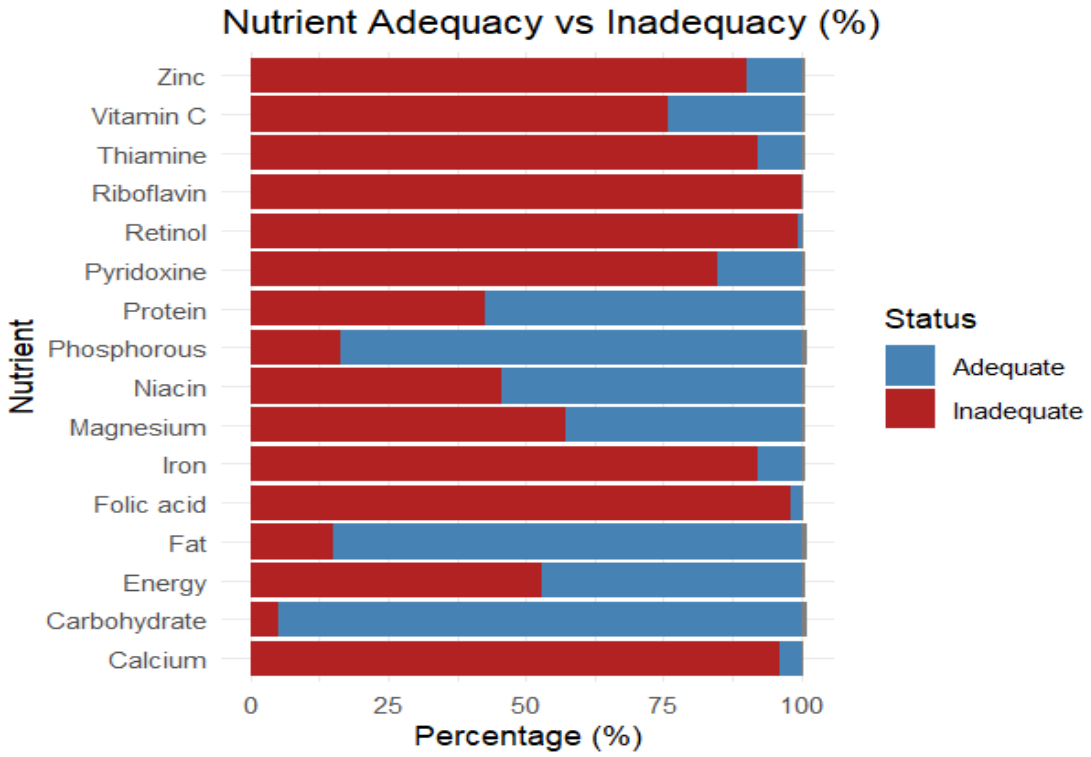

Fig. 2: Percent adequacy and inadequacy of nutrients in the diet of pregnant women

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Table 2: Nutrient Intake, Adequacy Ratios, and EAR Compliance in Pregnant Women

Nutrient	Mean	Median	Std.	EAR	%PW not meeting EAR	Mean NAR
Energy (Kcal/day)	1966.200	1961.100	527.340	2010	53	0.908
Protein (g/day)	59.816	56.747	21.127	53.6	42.75	0.898
Fat (g/day)	50.300	48.330	20.778	30	15	0.949
Carbohydrate (g/day)	324.236	325.355	100.708	135	5.25	0.994
Thiamine (mg/day)	1.153	1.151	0.331	1.6	92	0.711
Riboflavin (mg/day)	0.623	0.609	0.201	2.3	100	0.271
Niacin (mg/day)	11.916	11.427	4.881	11	46	0.891
Pyridoxine (mg/day)	1.412	1.370	0.472	1.9	84.75	0.717
Folic acid (µg/day)	211.346	181.879	103.878	480	98	0.439
Vitamin C (mg/day)	56.946	44.268	42.229	65	76	0.682
Retinol	108.849	104.850	71.263	406	99.5	0.266
Calcium (mg/day)	369.188	335.831	193.023	800	96	0.456
Magnesium (mg/day)	382.593	351.102	158.076	370	57.25	0.858
Phosphorous (mg/day)	1118.605	1154.100	303.208	800	16.25	0.972
Iron (mg/day)	13.573	12.807	4.376	21	92.25	0.637
Zinc (mg/day)	8.645	8.689	2.395	12	90	0.712
% Energy from Carbohydrate	65.442	64.747	18.831	45-65	13	
% Energy from fat	20.092	19.860	6.902	20-35	51.5	
% Energy from Protein	11.993	11.216	3.952	5-15	1.75	

Table 3: Analysis of Nutrient Intake Deviations from EAR with Corresponding t- and p-Values

Nutrient	(μ_0)/EAR	Sample Mean (M	t-value	p-value	Significance
Energy	2010	1966.19	-1.6614	0.09742	ns
Protein	53.6	59.82	5.8845	<0.001	***
Fat	30	50.299	19.54	<0.001	***
Carbohydrate	135	324.236	40.972	<0.001	***
Thiamine	1.6	1.15304	-26.998	<0.001	***
Riboflavin	2.3	0.6228652	-166.59	<0.001	***
Niacin	11	11.91572	3.7521	<0.001	***
Pyridoxine	1.9	1.411944	-20.671	<0.001	***
Folic acid	480	211.346	-51.725	<0.001	***
Vitamin C	65	56.98105	-3.7793	<0.001	***
Retinol	406	108.849	-87.64	<0.001	***
Calcium	800	369.1877	-44.638	<0.001	***
Magnesium	370	382.5935	1.5933	0.1119	ns
Phosphorous	800	1118.605	21.016	<0.001	***
Iron	21	13.573	-19.728	<0.001	***
Zinc	12	8.590568	-27.874	<0.001	***

Table 4: Factors affecting the mean adequacy ratio

Nutrient Index	Independent Variables	Estimate	Std. Error	t value	Pr(>|t|)
MAR	AOC	0.000	0.001	-0.042	0.967
	SES	0.009	0.001	6.608	<0.001
	Family structure	0.053	0.011	4.81	<0.001
	Caste	-0.001	0.006	-0.245	0.807
	Education	0.000	0.003	0.011	0.991
	Religion	-0.012	0.013	-0.929	0.354

AOC: age of conception, SES-socioeconomic status

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