

Impact Of Interbirth Interval on Child and Maternal Health Outcomes

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ABSTRACT

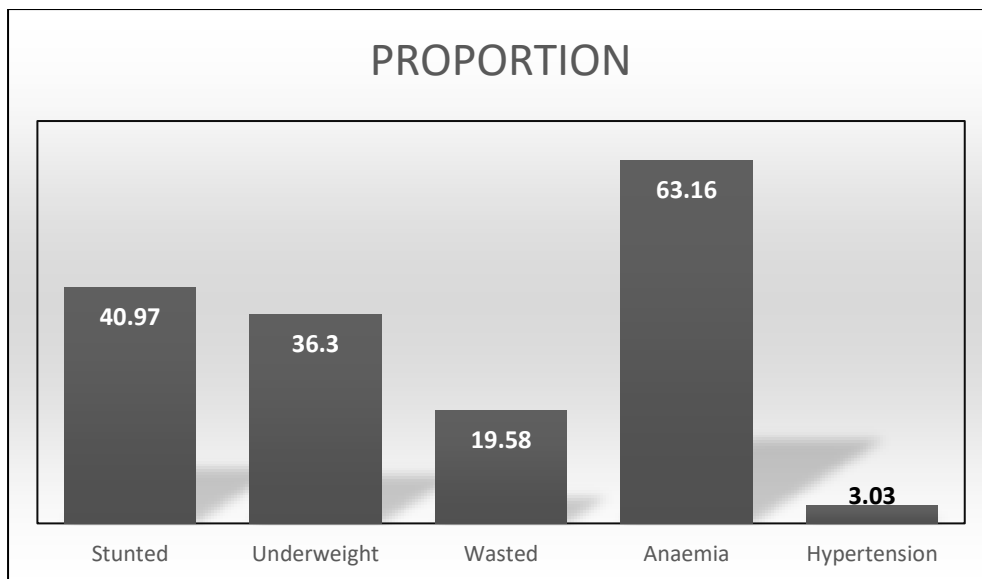
India as a country is blessed with an advantageous window for economic growth as it effectively maintains a fertility rate of 2 births per woman. It possesses a youthful demographic with 68% of its populace aged 15-64 and 25% in the 0-14 age bracket. However, it grapples with significant child and maternal health challenges, including child malnutrition. The Interbirth Interval (IBI) emerged as a crucial factor affecting child nutrition, highlighting shorter intervals' detrimental impact. This study is conducted to find association between IBI and child health outcomes of stunting, wasting and underweight along with maternal health outcomes of hypertension and anaemia. NFHS-5 data for 5 states is taken for the study and it was observed that shorter birth intervals of less than 11 months result in higher likelihood of stunting and underweight without having a significant impact on wasting outcomes. They are also more likely to increase stress disorders among women. Addressing these challenges necessitates efforts to elongate birth intervals, enhance reproductive autonomy, and intensify family planning initiatives using a comprehensive approach involving education, improved healthcare infrastructure, accessible contraceptives, and community engagement.

I. INTRODUCTION

India has surpassed China to be the most populous country in the world. It has also one of the youngest populations. Around 68% of the people lie in the age group of 15-64. While approximately 25% of the population is in the age group of 0-14. The country has successfully managed to attain a total fertility rate of 2 births per woman of reproductive age, a level that ensures population replacement. As a result, the working-age population in India is expanding in relation to the dependent younger population, presenting an advantageous window of opportunity for economic growth.

Nonetheless, India faces substantial challenges in the form of child mortality, child morbidity, child malnutrition, as well as issues like anaemia and stress disorders, primarily among women. It significantly contributes to global statistics concerning neonatal and infant mortality, common childhood illnesses, and child malnutrition. According to the World Health Organization (WHO), India records an infant mortality rate of 25 deaths per 1000 live births. Furthermore, India is home to a staggering 41.6 million children experiencing stunted growth. Additionally, the country faces a substantial challenge with a significant number of children being underweight and wasted. The latest data from the National Family Health Survey 2019-21 (NFHS-5) reveals that 32% and 19% of children under the age of 5 are found to be underweight and wasted, respectively (IIPS & ICF, [2019](#)). Child malnutrition, has thus, been responsible for a higher percentage of the country's burden of disease. Undernutrition affects cognitive and motor development and undermines educational attainment; and ultimately adversely impacts the productivity at work and at home, with adverse implications for income and economic growth. As a result, it time and again questions the inevitability of demographic dividend.

Hence, it is imperative to investigate the diverse factors contributing to this condition. Factors like poverty and limited resources, insufficient dietary access, substandard feeding practices, and inadequate healthcare availability significantly impact the well-being of children. Furthermore, inadequate maternal health and ineffective nutritional transmission from mothers to children can impede proper child growth. Anaemia in women is also recognized as a notable element in adverse birth outcomes such as premature birth and low birth weight. The prevalence of anaemia among women aged 15-49 has surged from 53% in 2015-16 (NFHS-4) to 57% in 2019-21 (NFHS-5).



In addition to the aforementioned elements, another aspect that receives comparatively less discussion is the duration between successive births. The spacing between childbirths and the total number of children a woman has are crucial factors that influence both child and maternal health outcomes. However, there is often a division in the literature regarding how this spacing is defined. Some studies focus on the gap between two live births, while others examine the time between the last pregnancy's outcome and the first month of the subsequent child's pregnancy, which is often referred to as the Interpregnancy interval.

In [2005](#), the World Health Organization (WHO) held a technical consultation on birth spacing, recommending that the interval between livebirths should be at least 24 months before attempting the next pregnancy. This recommendation aims to reduce the risks associated with adverse maternal, perinatal, and infant outcomes. The consultation also highlighted that shorter interval, specifically less than 6 months, are linked to an increased risk of maternal mortality, while intervals around or shorter than 18 months are associated with a higher risk of infant, neonatal, and perinatal mortality, low birth weight, small size for gestational age, and pre-term delivery.

II. LITERATURE REVIEW

Various studies by Abdulbari Bener et al. ([2012](#)), David Rousso([2002](#)), Conde-Agudelo et al.,([2005](#)) have investigated the relationship between interpregnancy interval (IPI) and low birth weight and other pregnancy outcomes and found out that short interpregnancy interval is associated with an increased risk of low birth weight, especially in younger and illiterate women. Another study by Conde-Agudelo et al. ([2000](#)), observed the impact on Maternal morbidity and mortality and found out women with interpregnancy intervals of 5 months or less had higher risks for maternal death, third trimester bleeding, premature rupture of membranes, and anaemia. A systematic literature review by Dewey and Cohen (2007) showed mixed results with regard to association between IPI and IBI and child anthropometric status. It also included various papers that investigated the impact on maternal anaemia and haemoglobin status. Dhamrait et al., ([2022](#)) also conducted a systemic review determining that both long and short birth spacing were associated with adverse child development outcomes."

While Interpregnancy interval is a reasonably effective indicator of birth spacing taking into account miscarriages, abortions and still births between two consecutive live births, it overlooks certain factors affecting child health outcomes that manifest after childbirth. For instance, it does not take into account the nutrition supplied to the child through breastfeeding. Moreover, it also fails to encompass the impact of total number of siblings and the attention deficit that arise. Interbirth interval provides an extended timeframe for examining child health outcomes, also enabling mothers to effectively transfer nutrients thereby affecting the overall well-being of children over a substantial duration. Therefore, in order to study child health outcomes such as stunting, underweight and wasting, the study has taken spacing between two consecutive births rather than relying solely on the interpregnancy interval.

Consequently, Rustein (2005) in his study, observed a discernible trend wherein chronic and general undernutrition appeared to rise consistently as the birth interval decreased. This was evident in the average adjusted odds ratios. Similarly, Fletcher et al. (1992) undertook research and discovered that birth intervals of fewer than 24 months were linked to increased odds of children being underweight. Additionally, Ricci and Becker (1996) identified an association between birth intervals and stunting outcomes. In the Indian context, numerous studies have consistently reported an association between shorter birth intervals and a heightened risk of stunting and underweight among children under the age of 5 (Chungkham et al., 2020, Dhingra & Pingali, 2021, Rustein, 2005). Another study by M. Shafiqur Rahman et al., (2016) has observed correlation between low birth weight and malnutrition among children. Kannaujiya et al., (2020) examined association between IPI and low birth weight and another study by him (2023) studied impact of IPI on 5 child health outcomes - neonatal and post-neonatal mortality, diarrhoea and/or acute respiratory infections (ARI), stunting, and underweight.

Although, a few studies in the Indian context have studied factors affecting malnutrition and maternal anaemia, questions remain if IPI is a good indicator to study these child health outcomes. In others where IBI is taken, questions remain whether those have accounted for unobserved heterogeneity. Various papers have included mother's age at conception and socio-economic conditions of households. There are other papers studying the Impact on stunting via birth order differences (2021) and also the impact of IPI on developmental outcomes in early childhood (2022).

Nevertheless, limited analysis has been conducted on the relationship between interbirth intervals and child and maternal health outcomes while considering all the potential confounding factors. Therefore, this paper seeks to enhance current research regarding child malnutrition by focusing on the impact of birth intervals. Additionally, it endeavours to encompass variables such as the overall count of children a mother has had, breastfeeding duration, and the educational and nutritional status of mothers, thus expanding the scope of investigation.

III. THEORETICAL MODEL

The theoretical framework provides a simplified overview of the potential relationships between interbirth intervals and child health outcomes. A study in western Kenya (2023) investigated the predictors of undernutrition. It stated, Stunting, a form of linear growth retardation, is often linked to recurring exposure to unfavourable economic circumstances, inadequate sanitation, and the combined impacts of insufficient energy and nutrient consumption alongside infections. On the other hand, being underweight for one's age signifies

a past of inadequate health or nutritional challenges for the child, including recurrent illnesses or periods of malnutrition. Conversely, being underweight for one's height indicates wasting, implying thinness and is typically linked to recent illness, failure to gain weight, or weight loss.

The existing literature cites various reasons as to why interpregnancy and interbirth interval will impact child and maternal health outcomes. A shorter birth interval doesn't allow the mother's body enough time to recover from the physical and physiological stresses of the previous pregnancy and childbirth. Also, if pregnancies are closely spaced, the mothers do not have sufficient time to replenish her nutrient stores, which negatively impacts the health and development of the subsequent child. This is often referred to as maternal nutrition depletion hypothesis (Agustin Conde-Agudelo; [2007](#)). It also adversely affects the child care practices of the parents. Siblings born in quick succession compete for parental care, time, and resources (financial, emotional, and cognitive), potentially compromising adequate care and supervision for each child. On the other hand, associations between longer IPIs and adverse birth outcomes have been interpreted as support for the physical regression hypothesis. According to this theory, the maternal body's physiological mechanisms are optimized for foetal growth during pregnancy and gradually diminish after delivery, resulting in a loss of beneficial physiological adaptations from the previous pregnancy. The impact of shorter birth intervals is augmented by socio-economic conditions of a household ([2022](#)). For instance, income/wealth levels are bound to impact child and maternal health outcomes. Shorter birth intervals are also associated with low birth weight which further pose risks for child malnutrition ([2016](#)).

In the maternal health analysis, a study focuses on anaemia, a condition where the count of red blood cells or the haemoglobin concentration within them falls below the standard levels. The reasoning behind this is that severe cases of anaemia can lead to inadequate cognitive and motor development in children. Besides iron deficiency and insufficient nutrition, having closely spaced pregnancies often results in instances of anaemia ([2012](#)). The World Health Organization ([WHO](#)) has also noted that consistent heavy menstrual bleeding, maternal blood volume expansion during pregnancy, and blood loss during and after childbirth are common contributors to anaemia.

During pregnancy, hypertension in women can result in preeclampsia, characterized by high blood pressure. Although no theoretical findings directly study the impact of Interbirth Interval (IBI) on hypertension, various papers have found a direct impact on Preeclampsia and Eclampsia. If left untreated, preeclampsia can progress to eclampsia, a life-threatening condition that can cause seizures, organ damage, and even death. Hypertension can adversely affect the postnatal care received by children, thereby impairing child health outcomes too.

IV. DATA

The study has used data from NFHS-5, nationally representative household covering over 99% of India's population. Unit level data is taken from the Kids recode. Interviews in NFHS-5 were conducted with 724,115 women of age 15-49 with response rate of 97%. The Kids recode contains entire information about the all children that were born in the 5 years prior to the date of survey to these women. All information regarding maternal and child health, reproductive practices and family planning are provided in the dataset. NFHS utilizes a stratified two-stage sampling approach, creating distinct samples for both urban and rural regions. Initially, in rural areas, Primary Sampling Units (villages) are selected based on proportional probability (PP), followed by a random selection of households. The same two-stage procedure is applied in

urban areas, where census enumeration blocks are chosen randomly using PP, and households are subsequently selected. Trained interviewers collect the data using standardized questionnaires. The International Institute for Population Sciences (IIPS) was the nodal agency for managing and conducting the survey under the stewardship of the Ministry of Health and Family Welfare, Government of India.

IV.a. Analytical Sample

The paper has used the NFHS-5 Kids recode file. This dataset has one record for every child of interviewed women, born in the five years preceding the survey. It contains the information related to the child's pregnancy and postnatal care and immunization and health. The data for the mother of each of these children is also included. The unit of analysis (case) in the file is the children of women born in the last 5 years (0-59 months).¹ It has information related to child health outcomes like child's birth weight, weight for height, height for age and weight for age statistics. In addition, data related to women is also included like maternal anaemia, flag for hypertension and other diseases. The file also contains certain household level characteristics like the wealth quintiles and residence related variables like state and type of residence for each child.

Our analysis includes all women who reported a pregnancy outcome in the last five years. In the National Family Health Survey (NFHS-5), a total of 7,24,115 women were interviewed. Among these interviewed women, 2,32,920 children were born in the 5 years before the survey. The study has filtered out data for 5 states namely Bihar, Uttar Pradesh, Jharkhand, Madhya Pradesh and Rajasthan. This leaves us with a sample size of 97,776 observations. The above states constitute the maximum to the overall number of stunted, underweight and wasted children in India. A total of 4647 children died in the last 5 years. Out of the total 97,776 observations, 33,711 observations are excluded since data about preceding birth interval is missing. 33,378 observations are first born babies and for the rest the data is missing. Preceding is the interval between two live births outcome.

Interbirth intervals have been created with the first interval being less than 11 months going up to 60 months and above with a gap of 5 months in between. The analytic sample for malnutrition excluded 7895 and 1862 births with missing information on height for age and weight for height respectively. The data for months of breastfeeding is not missing for more than 10000 observations. These observations have not been removed in view of sample size. The regression model, however, automatically takes care of it. The analytic sample for mortality analyses is different and contains 64065 observations. Simultaneously, the analytic sample for anaemia as well as hypertension also has 64065 observations. In case of stunting, the final sample consists of 56,170 observations after dropping all missing values for height for weight Z score. Similar process is adopted for underweight and wasting sample resulting in 57,970 and 56,446 observations.

IV.b. Dependent Variables

The dependent variables of the interest were occurrence of stunting, wasting and underweight to study the child health outcomes and anaemia and hypertension to study maternal health

outcomes. Stunting is coded as '1' if the height-for-age z-score is below minus two standard deviations (-2 SD) from the median of the reference population, and '0' otherwise. Likewise, underweight is coded as '1' if the weight-for-age z-score is below minus two standard deviations (-2 SD) from the median of the reference population, and '0' otherwise. Calculation of stunting and underweight are based on the international reference population released by WHO in April 2006 (and accepted by the Government of India (World Health Organization, 2006). For maternal health outcomes, Maternal anaemia is coded as '1' if mother has 'mild,' 'moderate' or 'severe' anaemia and '0' otherwise. Hypertension among women is also classified in a similar manner.

IV.c. Independent Variables

IBI i.e., the Interbirth Interval which is defined as the gap between two consecutive live births is the independent variable. IBI was categorized into 10 groups: <11 months, 12–17 months, 18–23 months, 24–29 months, and 30–35, 36-41, 42-47, 48-53, 54-59 and above 60 months.

IV.d. Control Variables

Control variables have been incorporated in the analysis to address unobserved variations that could influence child and maternal health outcomes apart from the interbirth interval. Drawing from existing literature, several variables pertaining to mothers, children, and households have been included in the model. Given the direct impact of nutrition transfer from mother to child on child health, the mother's BMI is considered. Additionally, the model encompasses the mother's education level (categorized into no education, primary, secondary, and higher education) as well as the total number of children a woman has borne, regardless of their survival status. This factor can potentially detrimentally affect the mother's health and, consequently, her child's health. Child-related variables include the duration of breastfeeding, the child's gender (male/female), and whether the child was desired or not (0 or 1). In terms of household-related variables, the study takes into account the type of residence (rural/urban) and wealth quintiles (ranging from poorest to richest)."

V. METHODOLOGY

The paper has used multivariable logistic regression model. This is because all the five dependent variables are binary. The logit model used gives us the log of odds of any outcome happening. The general model with a binary outcome and k predictors (categorical or continuous) is as follows-

$$\log (p^i / 1 - p^i) = \log \text{ odds of outcome} = \alpha + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k$$

i= *Stunting/ Wasting/ Underweight /anaemia/Hypertension*

x_1 =*Interbirth interval*

x_2 =*Wealth quintiles*

x_3 =*mother BMI*

x_4 =*mother education*

x_5 =*total number of children born to a mother*

x_6 =months of breastfeeding

x_7 =child wantedness

The odds ratios are obtained by taking the exponentiating the regression coefficients.

In certain instances, individual mothers have had multiple childbirths within the five years preceding the survey, creating a potential linkage between these births. To mitigate the influence of shared characteristics on child and maternal health outcomes, the study introduced family fixed effects. This was achieved through the computation of robust standard errors using `vce(cluster caseid)`, given that 'caseid' uniquely identifies each mother.

VI. DESCRIPTIVE STATISTICS

The table presented below offers a descriptive overview of births within the five years preceding the survey date. It displays the total number of births across different interbirth intervals for varying samples related to stunting, underweight, wasting, neonatal mortality, anaemia, and hypertension. Notably, the data reveals that the highest number of children were born within the 24–29 month interval, while the lowest number was recorded for intervals less than 11 months. Additionally, the table portrays the distribution of births based on different levels of maternal education. Mothers with no formal education have the highest number of children, whereas higher education appears to act as a positive deterrent to childbirth. The majority of the children born were desired, with approximately 5.4% in each sample being unwanted. About 40% of the births occurred within the poorest wealth quintile, and over 80% took place in rural areas. Examining state distribution, Uttar Pradesh displayed a notably higher percentage of births across all categories compared to other states. The majority of mothers have between 2 to 5 children, with approximately 3% to 14% of mothers having more than 5 children in each sample.

Table 1:

<i>ibi_interval</i>	<i>Stunting Sample</i>	<i>Underweight Sample</i>	<i>Wasting Sample</i>	<i>Anaemia</i>	<i>Hypertension</i>
<11	1145	1192	1170	1452	1452
12 -17	5,700	5890	5729	6695	6695
18- 23	10277	10610	10,356	11732	11732
24-29	10,751	11064	10770	12193	12193
30-35	7801	8085	7875	8782	8782
36-41	5,737	5931	5782	6461	6461
42-47	3910	4044	3952	4430	4430
48-53	2,939	3021	2930	3319	3319
54-59	2028	2104	2037	2319	2319
>60	5,876	6029	5845	6682	6682
<i>Total</i>	56,170	57970	56446	64065	64065

<i>State Distribution</i>	<i>Stunting Sample</i>	<i>Underweight Sample</i>	<i>Wasting Sample</i>	<i>Anaemia</i>	<i>Hypertension</i>
<i>Bihar</i>	12938	13426	13091	14748	14748
<i>Uttar Pradesh</i>	20746	21325	20716	23919	23919
<i>Rajasthan</i>	8004	8245	8017	8905	8905
<i>Jharkhand</i>	5769	5944	5770	6449	6449
<i>Madhya Pradesh</i>	8713	9030	8852	10044	10044
<i>Wealth Quintiles</i>	<i>Stunting Sample</i>	<i>Underweight Sample</i>	<i>Wasting Sample</i>	<i>Anaemia</i>	<i>Hypertension</i>
<i>Poorest</i>	22008	22821	22169	25310	25310
<i>Poor</i>	14412	14852	14518	16406	16406
<i>Middle</i>	8935	9207	8945	10138	10138
<i>Rich</i>	6458	6632	6472	7291	7291
<i>Richest</i>	4357	4458	4342	4920	4920
<i>Mother's Education</i>	<i>Stunting Sample</i>	<i>Underweight Sample</i>	<i>Wasting Sample</i>	<i>Anaemia</i>	<i>Hypertension</i>
<i>No Education</i>	21532	22313	21635	24881	24881
<i>Primary</i>	8789	9041	8807	10002	10002
<i>Secondary</i>	21364	22027	21534	24150	24150
<i>Higher</i>	4485	4589	4470	5032	5032
<i>Total Children to Mother</i>	<i>Stunting sample</i>	<i>Underweight sample</i>	<i>Wasting sample</i>	<i>Anaemia</i>	<i>Hypertension</i>
<i>2-5</i>	46781	52143	52538	62132	59132
<i>More Than 5</i>	8389	5827	3908	1933	4778
<i>Child Wanted</i>	<i>Stunting Sample</i>	<i>Underweight Sample</i>	<i>Wasting Sample</i>	<i>Anaemia</i>	<i>Hypertension</i>
<i>Mistimed</i>	2602	2667	2598	2959	2959
<i>Unwanted</i>	2999	3107	3025	3478	3478
<i>Wanted</i>	50569	52196	50823	57628	57628
<i>Residence</i>	<i>Stunting Sample</i>	<i>Underweight Sample</i>	<i>Wasting Sample</i>	<i>Anaemia</i>	<i>Hypertension</i>
<i>Urban</i>	7606	7824	7603	8683	8683
<i>Rural</i>	48564	50146	48843	55382	55382

The distribution of child and maternal health outcomes shows around 41% of children are moderately or severely stunted. For maternal health outcomes, more than 63% of women suffer

from mild/moderate or severe anaemia whereas a small 3% of women reported suffering from hypertension.

VII. UNIVARIATE ANALYSIS

Table 2 below shows a distribution of all health outcomes by interbirth interval (IBI). The proportion of stunted and underweight children falls as IBI increases. 51% and 43% of children with IBI<11 months were respectively stunted and underweight. While the proportion remains nearly constant for wasting outcomes. More than 8% of infants with IBI<11 months died within 28 days of birth. Prevalence of anaemia among women appears to hover around 64% without falling much in later birth intervals. While, 6.27% of women with IBI<11 reported hypertension, only 4.4% reported in IBI of 30-35 months.

When compared within different maternal education groups, the table shows that mothers with 0 years of schooling reported the maximum cases of stunting and underweight with 46% and 42% respectively. Neonatal mortality falls as mother's education level increases. Similar number is reported for anaemia. 65% of women with 0 years of schooling suffered from anaemia and 4.6% reported hypertension. On the other hand, 57% of women with higher education reported anaemia. However, no significant difference is seen for hypertension outcomes as schooling level rise.

A comparison of child and maternal health outcomes in different wealth quintiles show 47% births in poorest wealth quintile suffered stunting whereas 43.5% were underweight. 3% infants died with 28 days of birth in the poorest wealth quintile. All child health indicators exhibit a downward trend as the number of children born to a mother rises to more than 5. For instance, approximately 34% of children born to mothers with 2 to 5 children experience stunting, while this percentage increases to 71% for children born to mothers with more than 5 children. This pattern is consistent for underweight and wasting outcomes as well, with 81% and 43% of children being underweight and stunted, respectively, in households where more than 5 children are born to a mother. However, maternal health outcomes do not follow this pattern. Approximately 21% of mothers with more than 5 children are reported to be anaemic, and 3% have reported hypertension. In contrast, 64% of mothers with 2 to 5 children were found to be anaemic.

Children categorized as unwanted face a higher risk of stunting and being underweight compared to those who are wanted. However, this pattern doesn't hold for wasting outcomes. Notably, a smaller percentage of mistimed children experience stunting, being underweight, or wasting compared to wanted children. On the contrary, when considering neonatal mortality, timing becomes a significant factor. A greater proportion of mistimed or unwanted children die within the first 28 days of their birth than those who are wanted. Concerning maternal health outcomes, the likelihood of a mother being anaemic or suffering from hypertension increases when the child's birth is mistimed or unwanted.

Table 2:

<i>Category</i>	<i>Stunting</i>	<i>Underweight</i>	<i>Wasting</i>	<i>anaemia</i>	<i>Hypertension</i>

Interbirth Interval	percent	percent	percent	percent	percent
<11	51.09	43.20	18.97	64.39	6.27
12 -1 7	46.14	39.61	19.06	64.35	5.12
18- 23	44.56	38.32	19.33	63.54	4.57
24-29	42.69	38.22	19.34	63.48	4.86
30-35	39.81	36.19	19.90	63.04	4.43
36-41	39.46	35.47	20.11	62.95	5.57
42-47	37.93	32.69	19.61	63.70	4.88
48-53	36.30	32.37	20.03	62.76	5.30
54-59	36.05	33.13	19.29	61.19	4.05
>60	33.59	31.05	19.97	61.36	5.76
<i>Mother's education</i>	<i>Stunting</i>	<i>Underweight</i>	<i>Wasting</i>	<i>anaemia</i>	<i>Hypertension</i>
0	46.81	42.11	21.11	65.03	4.68
1	43.30	37.26	18.93	63.13	5.49
2	37.12	32.47	18.74	62.34	5.19
3	26.64	24.47	17.45	57.95	4.29
<i>Wealth</i>	<i>Stunting</i>	<i>Underweight</i>	<i>Wasting</i>	<i>anaemia</i>	<i>Hypertension</i>
Poorest	47.95	43.57	21.65	66.66	2.42
Poor	41.92	36.08	19.01	63.17	3
Middle	37.24	31.99	17.92	61.06	3.39
Rich	30.73	27.26	17.63	59.09	4.03
Richest	25.43	22.41	17.07	55.49	4.02
<i>Total children to a mother</i>	<i>Stunting</i>	<i>Underweight</i>	<i>Wasting</i>	<i>anaemia</i>	<i>Hypertension</i>
2-5	34.27	31.23	17.8	64.49	3.02
More than 5	71.61	81.67	43.35	21.48	3.31
<i>Child wanted</i>	<i>Stunting</i>	<i>Underweight</i>	<i>Wasting</i>	<i>anaemia</i>	<i>Hypertension</i>
Mistimed	38.88	34.55	19.53	67.71	4.19
Unwanted	43.25	37.48	18.52	65.01	4.81
Wanted	40.92	36.35	19.64	62.82	2.87

VIII. MULTIVARIABLE REGRESSION RESULTS

The results of the logistic regression model with stunting as the dependent variable are shown in the following table. It shows the likelihood of stunting falls as the interbirth interval rises. The base IBI is set at Group3 (18-23 months). The table shows that as compared to group3, children with a preceding birth interval of 11 months or less are more likely to be stunted. Similarly, for IBI group2(12-17months), the likelihood of stunting is 0.06 times more as compared to 18-23 months. On the other hand, for children in IBI groups of more than 24 months, the probability of stunting falls. Children in IBI Group=10 (more than 60 months) are significantly less likely (0.36 times) to be stunted as compared to the base interval. Children whose mothers have attained level of schooling are less likely to be stunted than mothers with 0 years of schooling. The impact is more as education level rises. Similarly, wealth quintiles of households are also a significant factor in determining stunting outcomes. Children in the richest wealth quintiles are 0.6 times less likely to be stunted. Mother's BMI also proves to be an important indicator as the likelihood of stunting falls as the former increases and this result is statistically significant. The total number of children ever born to a mother also play a very significant role as it increases the likelihood of stunted children. One interesting result is as the number of months of breastfeeding rises, the likelihood of stunting also rises. While the likelihood of stunting is less when the child is wanted as compared to when he/she is unwanted or mistimed. Almost all the results that are achieved are statistically significant at 95% confidence level. Similar tables are replicated for wasting, underweight, neonatal mortality among children and anaemia and hypertension among women. The tables are presented in the appendix.

Although the results show statistical significance for the underweight group, the same cannot be said for wasting. In other words, the interbirth interval is no longer a significant factor in explaining wasting outcomes. However, wealth, maternal education, and maternal BMI remain influential in wasting outcomes. Richer wealth quintiles and higher maternal education levels decrease the probability of wasting. Unlike stunting and underweight, an increase in the number of months of breastfeeding is associated with reduced likelihood of wasting.

Table 3: *Logit regression of IBI, wealth, mother education, mother BMI, total children on stunting, underweight and wasting.*

Variable	Stunting	Underweight	Wasting
motherbmi	-0.000 (7.20)**	-0.001 (11.36)**	-0.000 (7.66)**
totalchild_mother	0.063 (8.00)**	0.042 (5.38)**	-0.010 (1.05)
breastfed	0.016 (21.15)**	0.011 (14.85)**	-0.007 (7.70)**
1bn.mother_edu	-0.073 (2.42)*	-0.136 (4.50)**	-0.133 (3.67)**
2.mother_edu	-0.191 (7.66)**	-0.229 (9.07)**	-0.113 (3.77)**
3.mother_edu	-0.390 (8.85)**	-0.358 (8.01)**	-0.149 (2.92)**
1bn.ibi_group	0.193 (2.54)*	0.164 (2.16)*	-0.026 (0.28)
2.ibi_group	0.065 (-1.66)	0.078 (2.00)*	0.015 (0.31)

4.ibi_group	-0.092 (2.86)**	-0.022 (0.68)	-0.007 (0.19)
5.ibi_group	-0.173 (4.94)**	-0.094 (2.66)**	0.008 (0.19)
6.ibi_group	-0.183 (4.76)**	-0.123 (3.20)**	0.025 (0.54)
7.ibi_group	-0.204 (4.69)**	-0.206 (4.70)**	0.023 (0.44)
8.ibi_group	-0.278 (5.74)**	-0.213 (4.33)**	0.031 (0.54)
9.ibi_group	-0.251 (4.52)**	-0.150 (2.69)**	-0.033 (0.49)
10.ibi_group	-0.355 (9.26)**	-0.218 (5.65)**	0.054 (1.20)
2bn.wealth	-0.134 (5.28)**	-0.218 (8.52)**	-0.150 (4.94)**
3.wealth	-0.284 (9.19)**	-0.353 (11.18)**	-0.236 (6.33)**
4.wealth	-0.474 (12.76)**	-0.508 (13.31)**	-0.276 (6.20)**
5.wealth	-0.626 (12.89)**	-0.669 (13.36)**	-0.328 (5.78)**
2.rur_urb	-0.086 (2.65)**	-0.193 (5.85)**	-0.205 (5.47)**
2bn.wantedness	0.107(1.72)	0.019(0.30)	-0.122(1.63)
3.wantedness	0.087(1.84)	0.077 (1.6)	0.023(0.41)
_cons	0.105 (-1.25)	0.808 (7.71)**	-0.045 (0.40)
N	45,344	46,445	45,133

The predictive margins for stunting, wasting and underweight based on various factors have also been calculated and is shown in table 4. It shows, for the highest interval group (10 or more), the predicted probability of stunting is approximately 34% as compared to 46% for group 1. Similarly, for underweight outcome, the probability of a child being underweight falls from 41% to 32% as IBI rises from less than 11 months to more than 60 months. And, as determined by the logit regression results, wasting outcomes do not follow such a trend. The predicted probability of stunting outcomes is the highest for 'unwanted' children (approximately 39.5%), followed by 'wanted' children (approximately 39.1%). While, it is not seen for wasting and underweight samples. In other categories of wealth and mother's education, predicted probability margins falls with increase in education and wealth.

Table 4.0

<i>Covariates</i>	<i>MARGINS (Stunting sample)</i>	<i>MARGINS (underweight sample)</i>	<i>MARGINS (wasting sample)</i>
IBI_GROUP			
1	0.47	0.41	0.20
2	0.44	0.39	0.21
3	0.42	0.37	0.21
4	0.40	0.37	0.20
5	0.38	0.35	0.21
6	0.38	0.35	0.21
7	0.37	0.33	0.21
8	0.36	0.33	0.21
9	0.36	0.34	0.20
10	0.34	0.33	0.21

Table 4.3

<i>Covariates</i>	<i>MARGIN (Stunting sample)</i>	<i>MARGIN (underweight sample)</i>	<i>MARGIN (wasting sample)</i>
MOTHER EDUCATION			
0	0.42	0.39	0.22
1	0.40	0.36	0.20
2	0.37	0.34	0.20
3	0.33	0.31	0.20

Table 4.1

<i>Covariates</i>	<i>MARGIN (Stunting sample)</i>	<i>MARGIN (underweight sample)</i>	<i>MARGIN (wasting sample)</i>
WANTED/NOT MISTIMED	0.37	0.34	0.20
UNWANTED	0.40	0.35	0.19
WANTED	0.39	0.36	0.21

Table 4.4

<i>Covariates</i>	<i>MARGIN (Stunting Sample)</i>	<i>MARGIN (Underweight Sample)</i>	<i>MARGIN (Wasting Sample)</i>
WEALTH			
1	0.43	0.41	0.23
2	0.40	0.36	0.20
3	0.37	0.33	0.19
4	0.32	0.30	0.18
5	0.29	0.26	0.18

IX. MATERNAL HEALTH OUTCOMES

Regression analysis of IBI along with other factors on anaemia show that interbirth interval has no significant impact on maternal anaemia. The regression results are shown in the table below. Mothers with shorter IBI (less than 17 months) are more likely to be anaemic but there is no statistical significance. Other variables like BMI and months of breastfeeding reduce the likelihood of anaemic mothers. Wealth also plays a role in reducing the probability of anaemia among mothers. Household with the richest wealth quintile have lower likelihoods than the poorest households.

Table 5 Logit regression of association of IBI, wealth, mother education, mother BMI and other characteristics with anaemia outcome.

Variable	Anaemia (t-value)	Hypertension (t-value)
motherbmi	-0.000 (6.66)**	0.000 (4.31)**
totalchild_mother	0.023 (2.94)**	0.105 (5.58)**

breastfed	-0.007 (9.44)**	0.003 (1.80)
1bn.mother_edu	-0.030 (0.99)	0.175 (2.19)*
2.mother_edu	-0.010 (0.39)	0.232 (3.44)**
3.mother_edu	-0.082 (2.04)*	0.161 (1.49)
1bn.ibi_group	-0.001 (0.01)	-0.061 (0.29)
2.ibi_group	0.046 (1.25)	0.206 (2.00)*
4.ibi_group	0.004 (0.12)	0.030 (0.33)
5.ibi_group	-0.014 (0.43)	0.192 (2.05)*
6.ibi_group	0.021 (0.58)	0.206 (2.06)*
7.ibi_group	0.051 (1.24)	0.255 (2.31)*
8.ibi_group	0.027 (0.60)	0.282 (2.37)*
9.ibi_group	-0.030 (0.58)	0.237 (1.73)
10.ibi_group	-0.008 (0.22)	0.382 (4.13)**
2bn.wealth	-0.135 (5.30)**	0.105 (1.48)
3.wealth	-0.202 (6.73)**	0.180 (2.27)*
4.wealth	-0.273 (7.85)**	0.323 (3.62)**
5.wealth	-0.424 (9.84)**	0.252 (2.28)*
2bn.wantedness(unwanted)	-0.15(2.59)**	-0.003(0.02)
3.wantedness(wanted)	-0.241(5.20)**	-0.473(4.48)**
2.rur_urb	-0.034 (1.12)	-0.070 (0.89)
_cons	1.006 (14.63)**	-4.464 (28.39)**
N	50,074	50,074

A similar analysis was conducted by substituting anaemia with hypertension among women. The findings were quite intriguing. The positive coefficient of the mother's BMI indicates an increased probability of hypertension with higher BMI. The likelihood of hypertension escalates as the interbirth interval (IBI) increases. Mothers with an IBI of 12-17 months are 0.21 times more likely to experience hypertension, while this likelihood rises to 0.39 times for intervals exceeding 60 months. Wealth quintiles present a conflicting influence, revealing an increase in likelihood in the richest quintiles compared to the poorest ones. However, it's worth noting that mothers whose children were wanted at the time of birth experience less stress compared to those with mistimed or unwanted children. Thus, while there is no association between IBI and anaemia among women, larger birth intervals do in fact impact stress levels among women.

X. DISCUSSION

The major difference from the above studies is that we have considered interbirth interval rather than interpregnancy interval. IBI significantly explains child and maternal health outcomes after accounting for heterogeneity. IBI shorter than 18 months (IBI Group 1 and 2) were associated with higher risk of stunting and underweight as compared to IBIs of 18-23 months. The study also confirmed that likelihood of adverse child health outcomes fall as birth interval increases. Thus, longer IBI is protective of child health outcomes. The predictive margins also tell the same story. These results are in line with the existing literature by Kannaujia(2023), Chungkham et al., [2020](#), Dhingra & Pingali, [2021](#), Rustein, [2005](#). The paper also confirms the results of the Kenyan study. Variables like mother's BMI, maternal education and wealth quintiles hold significance in explaining adverse child health outcomes of stunting, underweight and wasting.

The duration of breastfeeding amplifies the probability of experiencing stunting and being underweight. This likelihood further intensifies, particularly in the case of exclusive breastfeeding (TableA.6, Appendix). While extensive research advocates against the early introduction of solid and semi-solid foods, relying solely on breastfeeding but insufficient and delayed exposure to foods rich in protein and carbohydrates also pose risks to child health outcomes.

In addition, other factors such as the total count of children ever born to a mother significantly influence child health outcomes related to stunting and being underweight. Household composition, particularly the number of children, divides the available resources among the siblings. Shorter intervals are expected to exacerbate this impact, as the child with a lower birth order will be weaned from breastfeeding due to the mother's limited ability to produce sufficient milk to meet the nutritional needs of growing infants. However, No such trend was seen in this study(Table A.7, Appendix). One reason could be that the paper takes into account the total number of children ever born and not total living children.

Interbirth intervals (IBI) do not demonstrate notable risks concerning women's anaemia levels, contrary to findings in some of the reviewed literature. Nonetheless, hypertension shows an increasing likelihood with extended birth intervals, potentially linked to maternal aging and reduced capacity to care for their children. Notably, child wantedness is a significant factor; the probability of hypertension escalates in cases of unwanted pregnancies. Such unplanned circumstances can heighten physiological stress in women, compounded by inadequate support from family and instability in health and finances. This data contributes to the current body of literature concerning the risks associated with Interbirth Intervals (IBI) and the desirability of having children in relation to maternal health outcomes.

The study presents significant contributions in several aspects. Previous research on birth spacing primarily focused on the association between Interpregnancy Intervals (IPI) and child health outcomes. However, this paper has delved into a more relevant variable, Interbirth Intervals (IBI), exploring associations not only with child health outcomes but also with maternal health outcomes, which directly affect child health. The inclusion of family fixed effects was crucial to eliminate potential dependencies between outcomes of children within the same family. Additionally, the study revealed unique and intriguing associations between

the duration of breastfeeding and health outcomes, suggesting the need to reconsider infant feeding practices. Future extensions of this research could involve analysing IBIs based on sex and birth order, and considering the age of the child, especially when interacting with months of breastfeeding, to better understand its role in determining health outcomes.

XI. CONCLUSION

Child and maternal health outcomes serve as crucial indicators of a nation's economic development. A higher percentage of undernourished children directly affects a country's demographic window, impeding the transition to growth. Moreover, shorter intervals between births elevate stress levels among women, resulting in conditions such as preeclampsia and organ damage. This study aimed to assess the health and nutritional status of Indian children and women, determining the prevalence and factors contributing to malnutrition, with the ultimate goal of reducing morbidity in both child and maternal populations.

The findings demonstrated a clear link between interbirth intervals and the occurrence of undernutrition, highlighting that shorter interval increase the probability of adverse health outcomes. Consequently, our results emphasize the need to address the burden of brief interbirth intervals. Enhancing women's reproductive autonomy and intensifying family planning efforts stand at the forefront of this initiative. It is imperative to elongate the gap between births to ensure adequate replenishment of maternal nutrition and appropriate transfer of nutrition to children. Additionally, addressing stress levels in women is crucial, as it elevates blood pressure and the risk of stroke. Ischemic heart disease ranks among the top causes of female mortality in India, as reported by the [World Health Organization](#).

To achieve this, a comprehensive approach involving diverse stakeholders and strategies is vital. This could include comprehensive education targeting girls and women, improving accessibility to information about family planning methods and contraceptives. Effective mechanisms, such as counselling during antenatal visits by healthcare providers, can be instrumental. Moreover, fortifying healthcare infrastructure and guaranteeing access to a wide array of affordable and high-quality contraceptive options in both urban and rural areas would cater to the varied needs and preferences of individuals. Community-based awareness programs that engage both men and women in discussions are pivotal public health tools and hold promise as practical, cost-effective, and sustainable approaches to safeguarding the well-being of children and mothers.

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XIII. APPENDIX

Table A.1

Logit regression of association of IBI, wealth, mother education, mother BMI and other characteristics with stunting outcome.

```

Iteration 0: log pseudolikelihood = -30323.194
Iteration 1: log pseudolikelihood = -29316.998
Iteration 2: log pseudolikelihood = -29309.037
Iteration 3: log pseudolikelihood = -29309.028
Iteration 4: log pseudolikelihood = -29309.028

Logistic regression
Log pseudolikelihood = -29309.028
Number of obs = 45,344
Wald chi2(24) = 1776.92
Prob > chi2 = 0.0000
Pseudo R2 = 0.0334
(Std. Err. adjusted for 43,800 clusters in caseid)

```

stunting	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]	
motherbmi	-.0002709	.0000355	-7.63	0.000	-.0003405	-.0002013
breastfed	.0158084	.0007426	21.29	0.000	.0143529	.0172639
totalchild_mother	.054473	.0079446	6.86	0.000	.0389019	.0700441
mother_edu						
1	-.0640528	.0300918	-2.13	0.033	-.1230316	-.005074
2	-.1911573	.0252451	-7.57	0.000	-.2406368	-.1416778
3	-.4318273	.044361	-9.73	0.000	-.5187734	-.3448813
2.rur_urb	-.0908501	.0327523	-2.77	0.006	-.1550435	-.0266567
state						
9	.3179327	.0322061	9.87	0.000	.2548099	.3810555
10	.1930521	.0353349	5.46	0.000	.123797	.2623072
20	.1275756	.0421317	3.03	0.002	.0449991	.2101522
23	.0616151	.0376766	1.64	0.102	-.0122296	.1354598
ibi_group						
1	.1660777	.0756745	2.19	0.028	.0177585	.314397
2	.0562144	.0391246	1.44	0.151	-.0204683	.1328972
4	-.090269	.0322688	-2.80	0.005	-.1535146	-.0270234
5	-.1722069	.0351857	-4.89	0.000	-.2411696	-.1032441
6	-.1861391	.0383863	-4.85	0.000	-.2613748	-.1109034
7	-.2056327	.0435419	-4.72	0.000	-.2909734	-.1202921
8	-.2845592	.0486943	-5.84	0.000	-.3799982	-.1891201
9	-.2603885	.0557011	-4.67	0.000	-.3695606	-.1512165
10	-.3641885	.0385834	-9.44	0.000	-.4398106	-.2885665
wealth						
2	-.1381021	.0256165	-5.39	0.000	-.1883095	-.0878947
3	-.2783742	.0316321	-8.80	0.000	-.340372	-.2163764
4	-.4636739	.0381314	-12.16	0.000	-.5384101	-.3889376
5	-.6141138	.0497717	-12.34	0.000	-.7116644	-.5165631
_cons	.0187893	.0904822	0.21	0.835	-.1585526	.1961312

Table A.2

Margins Calculation for Stunting sample

Predictive margins		Number of obs		=		45,344	
Model VCE		: Robust					
Expression		: Pr(stunting), predict()					
	Delta-method						
	Margin	Std. Err.	z	P> z	[95% Conf. Interval]		
<i>ibi_group</i>							
1	.4599857	.0171701	26.79	0.000	.4263328	.4936385	
2	.4339418	.0074433	58.30	0.000	.4193533	.4485304	
3	.4207398	.0054322	77.45	0.000	.4100929	.4313866	
4	.3997713	.005221	76.57	0.000	.3895383	.4100043	
5	.3810353	.0060073	63.43	0.000	.3692612	.3928094	
6	.3778814	.0069067	54.71	0.000	.3643445	.3914184	
7	.3734852	.0082739	45.14	0.000	.3572688	.3897017	
8	.355896	.0094246	37.76	0.000	.3374241	.3743678	
9	.3612454	.0112235	32.19	0.000	.3392479	.383243	
10	.3385211	.0065895	51.37	0.000	.3256059	.3514363	
<i>wealth</i>							
1	.4323988	.0041999	102.96	0.000	.4241672	.4406304	
2	.3997906	.0045344	88.17	0.000	.3909033	.4086779	
3	.3675356	.005693	64.56	0.000	.3563776	.3786936	
4	.3266763	.0067596	48.33	0.000	.3134278	.3399247	
5	.2952655	.0088082	33.52	0.000	.2780018	.3125292	
<i>mother_edu</i>							
0	.4174766	.0040796	102.33	0.000	.4094808	.4254724	
1	.4025162	.0058132	69.24	0.000	.3911225	.4139099	
2	.3733648	.003759	99.33	0.000	.3659973	.3807322	
3	.3206628	.0082307	38.96	0.000	.3045309	.3367948	

Table A.3

Logit regression of association of IBI, wealth, mother education, mother BMI and other characteristics with underweight outcome.

Iteration 0: log pseudolikelihood = -30280.519						
Iteration 1: log pseudolikelihood = -29342.617						
Iteration 2: log pseudolikelihood = -29323.077						
Iteration 3: log pseudolikelihood = -29323.053						
Iteration 4: log pseudolikelihood = -29323.053						
Logistic regression			Number of obs	=	46,445	
			Wald chi2(20)	=	1564.05	
			Prob > chi2	=	0.0000	
Log pseudolikelihood = -29323.053			Pseudo R2	=	0.0316	
(Std. Err. adjusted for 44,811 clusters in caseid)						
underweight	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]	
motherbmi	-.0005234	.0000461	-11.36	0.000	-.0006137	-.0004331
breastfed	.0109531	.0007375	14.85	0.000	.0095076	.0123985
totalchild_mother	.0424925	.0078917	5.38	0.000	.0270251	.0579599
mother_edu						
1	-.1362624	.030312	-4.50	0.000	-.1956729	-.0768519
2	-.2285562	.0251987	-9.07	0.000	-.2779448	-.1791676
3	-.3575669	.0446521	-8.01	0.000	-.4450833	-.2700504
ibi_group						
1	.164372	.0759807	2.16	0.031	.0154527	.3132914
2	.0784998	.0391905	2.00	0.045	.0016878	.1553118
4	-.0218602	.0323727	-0.68	0.500	-.0853096	.0415891
5	-.0937068	.0351724	-2.66	0.008	-.1626434	-.0247703
6	-.1227983	.0384272	-3.20	0.001	-.1981143	-.0474824
7	-.2064708	.0439515	-4.70	0.000	-.2926142	-.1203273
8	-.2128159	.0491017	-4.33	0.000	-.3090536	-.1165783
9	-.1497119	.0556506	-2.69	0.007	-.258785	-.0406387
10	-.2180117	.0385949	-5.65	0.000	-.2936563	-.1423671
wealth						
2	-.2183824	.0256404	-8.52	0.000	-.2686367	-.168128
3	-.3532178	.0316002	-11.18	0.000	-.4151532	-.2912825
4	-.5079186	.038156	-13.31	0.000	-.582703	-.4331341
5	-.6692248	.0500993	-13.36	0.000	-.7674177	-.571032
2.rur_urb	-.1928198	.0329328	-5.85	0.000	-.257367	-.1282726
_cons	.8081816	.1048032	7.71	0.000	.6027712	1.013592

Table A.4 Margins calculation for Underweight Sample

Predictive margins		Number of obs		= 46,445		
Model VCE : Robust						
Expression : Pr(underweight), predict()						
	Delta-method					
	Margin	Std. Err.	z	P> z	[95% Conf. Interval]	
ibi_group						
1	.4120723	.016856	24.45	0.000	.3790351 .4451094	
2	.3922346	.0072322	54.23	0.000	.3780597 .4064095	
3	.3743898	.0052559	71.23	0.000	.3640885 .3846911	
4	.3694757	.0050922	72.56	0.000	.3594952 .3794563	
5	.3535106	.005815	60.79	0.000	.3421134 .3649077	
6	.3471318	.0066885	51.90	0.000	.3340227 .3602409	
7	.3290822	.0079396	41.45	0.000	.3135208 .3446436	
8	.3277322	.0091826	35.69	0.000	.3097346 .3457298	
9	.341277	.0109396	31.20	0.000	.3198357 .3627182	
10	.3266288	.006489	50.34	0.000	.3139106 .3393469	
wealth						
1	.4080043	.0040913	99.72	0.000	.3999854 .4160231	
2	.3576159	.0044472	80.41	0.000	.3488997 .3663322	
3	.3278993	.005525	59.35	0.000	.3170706 .338728	
4	.2954035	.006515	45.34	0.000	.2826343 .3081728	
5	.2635616	.0083931	31.40	0.000	.2471115 .2800117	
mother_edu						
0	.3883753	.0039767	97.66	0.000	.3805812 .3961694	
1	.357517	.0056292	63.51	0.000	.3464841 .36855	
2	.3372279	.0036445	92.53	0.000	.3300848 .3443711	
3	.3098229	.0081713	37.92	0.000	.2938075 .3258383	

Table A.5 *Logit regression of association of IBI, wealth, mother education, mother BMI and other characteristics with wasting outcome.*

```

Iteration 0:  log pseudolikelihood = -23012.384
Iteration 1:  log pseudolikelihood = -22819.207
Iteration 2:  log pseudolikelihood = -22814.088
Iteration 3:  log pseudolikelihood = -22814.083
Iteration 4:  log pseudolikelihood = -22814.083

Logistic regression              Number of obs   =   45,133
                                Wald chi2(20)    =   314.79
                                Prob > chi2       =   0.0000
Log pseudolikelihood = -22814.083  Pseudo R2      =   0.0086

```

(Std. Err. adjusted for 43,581 clusters* in caseid)

wasting	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]	
motherbmi	-.0003659	.0000478	-7.66	0.000	-.0004595	-.0002722
breastfed	-.0069844	.0009074	-7.70	0.000	-.008763	-.0052059
totalchild_mother	-.0100568	.0095479	-1.05	0.292	-.0287704	.0086568
mother_edu						
1	-.1333113	.0363265	-3.67	0.000	-.2045099	-.0621127
2	-.1125561	.0298637	-3.77	0.000	-.1710879	-.0540243
3	-.149381	.0511652	-2.92	0.004	-.2496629	-.0490991
ibi_group						
1	-.0255673	.0929364	-0.28	0.783	-.2077194	.1565847
2	.0147031	.0473105	0.31	0.756	-.0780238	.1074299
4	-.0074349	.0388825	-0.19	0.848	-.0836432	.0687735
5	.0078465	.0419705	0.19	0.852	-.0744141	.0901072
6	.024678	.0454499	0.54	0.587	-.0644022	.1137582
7	.0226354	.0512209	0.44	0.659	-.0777557	.1230265
8	.0310843	.0571074	0.54	0.586	-.0808441	.1430126
9	-.0325001	.0662601	-0.49	0.624	-.1623675	.0973673
10	.0539329	.0448758	1.20	0.229	-.0340221	.1418878
wealth						
2	-.1498375	.0303156	-4.94	0.000	-.209255	-.0904201
3	-.2357407	.037214	-6.33	0.000	-.3086789	-.1628026
4	-.2764116	.0445543	-6.20	0.000	-.3637365	-.1890867
5	-.3275764	.0567148	-5.78	0.000	-.4387353	-.2164176
2.rur_urb	-.2048927	.0374716	-5.47	0.000	-.2783357	-.1314497
_cons	-.0448377	.1131764	-0.40	0.692	-.2666593	.1769839

Table A.6

Margins calculation for wasting

Predictive margins		Number of obs		= 45,133		
Model VCE : Robust						
Expression : Pr(wasting), predict()						
	Delta-method				[95% Conf. Interval]	
	Margin	Std. Err.	z	P> z		
<i>ibi_group</i>						
1	.2009763	.0141246	14.23	0.000	.1732927	.2286599
2	.2074651	.0062309	33.30	0.000	.1952527	.2196776
3	.2050784	.0045253	45.32	0.000	.1962089	.2139479
4	.2038792	.0043779	46.57	0.000	.1952988	.2124597
5	.2063496	.0050836	40.59	0.000	.1963859	.2163134
6	.2090959	.0058611	35.68	0.000	.1976084	.2205834
7	.2087612	.0070224	29.73	0.000	.1949976	.2225248
8	.2101481	.0081756	25.70	0.000	.1941243	.226172
9	.1998745	.0095125	21.01	0.000	.1812305	.2185186
10	.2139324	.005802	36.87	0.000	.2025607	.2253042
<i>wealth</i>						
1	.2294984	.00356	64.47	0.000	.222521	.2364759
2	.2042176	.0038032	53.70	0.000	.1967635	.2116717
3	.1906806	.0046469	41.03	0.000	.1815728	.1997884
4	.1845138	.0055518	33.23	0.000	.1736324	.1953952
5	.1769753	.0071255	24.84	0.000	.1630095	.1909411
<i>mother_edu</i>						
0	.2196145	.0034793	63.12	0.000	.2127952	.2264337
1	.1977735	.0048033	41.17	0.000	.1883591	.2071878
2	.201064	.0031456	63.92	0.000	.1948987	.2072293
3	.1952535	.0069213	28.21	0.000	.1816881	.208819

Table.7

Logit regression of association of IBI, wealth, mother education, mother BMI and other characteristics in case of exclusive breastfeeding.

```

. logit stunting motherbmi breastfed totalchild_mother i.mother_edu ib3.ibi_group i.wealth i.rur_urb
> b i.wantedness if exclusive==0 , vce(cluster caseid)

Iteration 0:  log pseudolikelihood = -23695.95
Iteration 1:  log pseudolikelihood = -22961.226
Iteration 2:  log pseudolikelihood = -22956.466
Iteration 3:  log pseudolikelihood = -22956.462
Iteration 4:  log pseudolikelihood = -22956.462

Logistic regression              Number of obs   =    35,526
                                Wald chi2(22)    =    1315.31
                                Prob > chi2       =    0.0000
Log pseudolikelihood = -22956.462  Pseudo R2      =    0.0312

                                (Std. Err. adjusted for 35,526 clusters in caseid)

```

stunting	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]	
motherbmi	-.0002426	.000037	-6.56	0.000	-.0003152	-.0001701
breastfed	.0190993	.0008692	21.97	0.000	.0173957	.0208029
totalchild_mother	.0527337	.0092202	5.72	0.000	.0346624	.070805
mother_edu						
1	-.0332222	.0337583	-0.98	0.325	-.0993872	.0329429
2	-.1695794	.0281216	-6.03	0.000	-.2246967	-.114462
3	-.3645335	.0503869	-7.23	0.000	-.4632901	-.2657769
ibi_group						
1	.1674292	.087401	1.92	0.055	-.0038736	.338732
2	.0868998	.0449035	1.94	0.053	-.0011095	.1749091
4	-.0710628	.0365194	-1.95	0.052	-.1426395	.0005139
5	-.1510704	.0397038	-3.80	0.000	-.2288884	-.0732525
6	-.175088	.0433934	-4.03	0.000	-.2601375	-.0900384
7	-.1367782	.0488552	-2.80	0.005	-.2325326	-.0410239
8	-.2488897	.0545721	-4.56	0.000	-.355849	-.1419304
9	-.2274121	.0629358	-3.61	0.000	-.350764	-.1040601
10	-.3290772	.0433032	-7.60	0.000	-.41395	-.2442045
wealth						
2	-.1314885	.0285039	-4.61	0.000	-.1873551	-.075622
3	-.2555613	.0347764	-7.35	0.000	-.3237218	-.1874008
4	-.4521869	.0418682	-10.80	0.000	-.5342472	-.3701267
5	-.5732656	.0553125	-10.36	0.000	-.6816761	-.4648551
2.rur_urb	-.0692827	.0372098	-1.86	0.063	-.1422127	.0036472
wantedness						
unwanted	.1300782	.0713909	1.82	0.068	-.0098454	.2700017
wanted	.0814011	.0546301	1.49	0.136	-.0256721	.1884742
_cons	-.0965415	.1055153	-0.91	0.360	-.3033477	.1102647

Table A.8a

Logit regression of association of IBI, wealth, mother education, mother BMI and other characteristics in case of Total children –(less than 4).

```

. logit stunting motherbmi breastfed totalchild_mother i.mother_edu ib3.ibi_group i.wealth i.rur_ur
> b i.wantedness if totalchildren==0 , vce(cluster caseid)

Iteration 0:  log pseudolikelihood = -26112.315
Iteration 1:  log pseudolikelihood = -25348.659
Iteration 2:  log pseudolikelihood = -25342.752
Iteration 3:  log pseudolikelihood = -25342.747
Iteration 4:  log pseudolikelihood = -25342.747

Logistic regression                Number of obs   =    39,393
                                   Wald chi2(22)    =    1368.89
                                   Prob > chi2       =    0.0000
Log pseudolikelihood = -25342.747  Pseudo R2      =    0.0295

                                   (Std. Err. adjusted for 38,207 clusters in caseid)

```

stunting	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]	
motherbmi	-.0002581	.0000374	-6.89	0.000	-.0003314	-.0001847
breastfed	.0158841	.0008078	19.66	0.000	.0143009	.0174673
totalchild_mother	.0810442	.0148189	5.47	0.000	.0519997	.1100888
mother_edu						
1	-.0609596	.0327914	-1.86	0.063	-.1252297	.0033104
2	-.1768616	.0264861	-6.68	0.000	-.2287735	-.1249498
3	-.3749996	.0453012	-8.28	0.000	-.4637883	-.286211
...						
ibi_group						
1	.2331476	.0826237	2.82	0.005	.0712081	.3950871
2	.0773947	.0417566	1.85	0.064	-.0044468	.1592361
4	-.1037909	.0348722	-2.98	0.003	-.1721392	-.0354426
5	-.1390873	.0376789	-3.69	0.000	-.2129366	-.0652379
6	-.1849116	.0414895	-4.46	0.000	-.2662295	-.1035937
7	-.1688746	.0465548	-3.63	0.000	-.2601203	-.0776288
8	-.2805335	.0526661	-5.33	0.000	-.383757	-.1773099
9	-.2744083	.0605605	-4.53	0.000	-.3931046	-.1557119
10	-.3472262	.0415831	-8.35	0.000	-.4287276	-.2657249
wealth						
2	-.127441	.0274391	-4.64	0.000	-.1812206	-.0736615
3	-.2765163	.0330212	-8.37	0.000	-.3412368	-.2117959
4	-.4563629	.0390142	-11.70	0.000	-.5328294	-.3798964
5	-.6292584	.0506686	-12.42	0.000	-.7285671	-.5299497
2.rur_urb	-.098982	.0343454	-2.88	0.004	-.1662978	-.0316662
wantedness						
unwanted	.0954974	.0701001	1.36	0.173	-.0418962	.232891
wanted	.0997035	.0492238	2.03	0.043	.0032267	.1961804
_cons	-.0135022	.1060956	-0.13	0.899	-.2214458	.1944413

Table A.8b

Logit regression of association of IBI, wealth, mother education, mother BMI and other characteristics in case of Total children –(more than 5).

```

. logit stunting motherbmi breastfed totalchild_mother i.mother_edu ib3.ibi_group i.wealth i.rur_ur
> b i.wantedness if totalchildren==1 , vce(cluster caseid)

Iteration 0:  log pseudolikelihood = -4115.5972
Iteration 1:  log pseudolikelihood = -4014.4251
Iteration 2:  log pseudolikelihood = -4014.2117
Iteration 3:  log pseudolikelihood = -4014.2116

Logistic regression              Number of obs   =    5,951
                                Wald chi2(22)    =   185.08
                                Prob > chi2       =    0.0000
Log pseudolikelihood = -4014.2116 Pseudo R2       =    0.0246

                                (Std. Err. adjusted for 5,593 clusters in caseid)

```

stunting	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]	
motherbmi	-.000168	.0000677	-2.48	0.013	-.0003007	-.0000352
breastfed	.0139222	.0018766	7.42	0.000	.010244	.0176003
totalchild_mother	-.0064018	.0231096	-0.28	0.782	-.0516959	.0388922
mother_edu						
1	-.1389535	.0751727	-1.85	0.065	-.2862893	.0083822
2	-.2505072	.0819316	-3.06	0.002	-.4110902	-.0899241
3	-.0057152	.3095459	-0.02	0.985	-.6124141	.6009837
ibi_group						
1	-.0155436	.1898471	-0.08	0.935	-.3876372	.35655
2	.0234519	.11505	0.20	0.838	-.2020419	.2489458
4	-.0511831	.0873644	-0.59	0.558	-.2224141	.120048
5	-.4154323	.0974116	-4.26	0.000	-.6063556	-.224509
6	-.2103415	.1027921	-2.05	0.041	-.4118102	-.0088728
7	-.4687094	.1197959	-3.91	0.000	-.7035051	-.2339138
8	-.3067684	.1273495	-2.41	0.016	-.5563688	-.0571679
9	-.1927686	.1425774	-1.35	0.176	-.4722152	.0866781
10	-.4430904	.1018561	-4.35	0.000	-.6427247	-.243456
wealth						
2	-.1496289	.066237	-2.26	0.024	-.279451	-.0198067
3	-.3028208	.0902946	-3.35	0.001	-.479795	-.1258465
4	-.6488927	.1326607	-4.89	0.000	-.9089029	-.3888825
5	-.4600889	.1897162	-2.43	0.015	-.8319258	-.0882521
2.rur_urb	.0123308	.1025672	0.12	0.904	-.1886972	.2133588
wantedness						
unwanted	-.0863883	.1979201	-0.44	0.662	-.4743045	.3015279
wanted	-.1541011	.1889157	-0.82	0.415	-.524369	.2161669
_cons	.5413625	.2901115	1.87	0.062	-.0272457	1.109971

Table A.9

Logit regression of association of IBI, wealth, mother education, mother BMI and other characteristics with anaemia outcome.

```
. logit anaemia motherbmi totalchild_mother breastfed i.mother_edu ib3.ibi_group i.wealth i.rur_urb
> , vce(cluster caseid)

Iteration 0:  log pseudolikelihood = -33408.314
Iteration 1:  log pseudolikelihood = -33174.995
Iteration 2:  log pseudolikelihood = -33174.854
Iteration 3:  log pseudolikelihood = -33174.854

Logistic regression               Number of obs   =   50,074
                                Wald chi2(20)    =   414.47
                                Prob > chi2       =   0.0000
Log pseudolikelihood = -33174.854 Pseudo R2       =   0.0070

                                (Std. Err. adjusted for 47,791 clusters in caseid)
```

anaemia	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]	
motherbmi	-.0001554	.0000233	-6.66	0.000	-.0002011	-.0001097
totalchild_mother	.0231474	.0078757	2.94	0.003	.0077113	.0385835
breastfed	-.0065049	.000689	-9.44	0.000	-.0078553	-.0051546
mother_edu						
1	-.0296031	.0300336	-0.99	0.324	-.0884678	.0292617
2	-.0097185	.0248174	-0.39	0.695	-.0583597	.0389227
3	-.0815282	.0400067	-2.04	0.042	-.1599399	-.0031164
ibi_group						
1	-.0005833	.0705736	-0.01	0.993	-.1389051	.1377385
2	.0464874	.0372741	1.25	0.212	-.0265684	.1195432
4	.0036935	.030915	0.12	0.905	-.0568987	.0642858
5	-.0143441	.0333149	-0.43	0.667	-.0796401	.0509519
6	.0208935	.0362638	0.58	0.565	-.0501821	.0919692
7	.0508654	.0410144	1.24	0.215	-.0295214	.1312523
8	.0272844	.0451777	0.60	0.546	-.0612622	.1158311
9	-.0296633	.0512856	-0.58	0.563	-.1301811	.0708545
10	-.0077034	.0353207	-0.22	0.827	-.0769306	.0615238
wealth						
2	-.1354418	.0255509	-5.30	0.000	-.1855207	-.085363
3	-.202137	.0300453	-6.73	0.000	-.2610247	-.1432493
4	-.2728501	.0347712	-7.85	0.000	-.3410005	-.2046998
5	-.424387	.0431314	-9.84	0.000	-.5089231	-.339851
2.rur_urb	-.0341243	.0304092	-1.12	0.262	-.0937251	.0254766
_cons	1.006079	.0687577	14.63	0.000	.8713165	1.140842

Table A.10

Logit regression of association of IBI, wealth, mother education, mother BMI and other characteristics with Hypertension outcome.

```

. logit hypertension motherbmi totalchild_mother breastfed i.mother_edu ib3.ibi_group i.wealth i.ru
> r_urb, vce(cluster caseid)

Iteration 0:  log pseudolikelihood = -7364.6858
Iteration 1:  log pseudolikelihood = -7306.5967
Iteration 2:  log pseudolikelihood = -7303.3703
Iteration 3:  log pseudolikelihood = -7303.3578
Iteration 4:  log pseudolikelihood = -7303.3578

Logistic regression              Number of obs   =    50,074
                                Wald chi2(20)   =    125.60
                                Prob > chi2     =    0.0000
Log pseudolikelihood = -7303.3578 Pseudo R2      =    0.0083

                                (Std. Err. adjusted for 47,791 clusters in caseid)

```

hypertension	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]	
motherbmi	.0001591	.0000369	4.31	0.000	.0000868	.0002314
totalchild_mother	.1050028	.0188133	5.58	0.000	.0681294	.1418763
breastfed	.0032711	.0018222	1.80	0.073	-.0003003	.0068425
mother_edu						
1	.1750343	.0801043	2.19	0.029	.0180326	.3320359
2	.2315774	.0672432	3.44	0.001	.0997832	.3633716
3	.161054	.1084364	1.49	0.137	-.0514774	.3735853
ibi_group						
1	-.0610503	.2095375	-0.29	0.771	-.4717363	.3496356
2	.2057264	.1026503	2.00	0.045	.0045355	.4069174
4	.0298779	.0898427	0.33	0.739	-.1462106	.2059664
5	.1917926	.0934008	2.05	0.040	.0087304	.3748547
6	.2061802	.1001682	2.06	0.040	.0098541	.4025063
7	.2545724	.1101886	2.31	0.021	.0386067	.4705382
8	.2819183	.1188191	2.37	0.018	.0490371	.5147994
9	.2372285	.1368281	1.73	0.083	-.0309496	.5054067
10	.381527	.0924462	4.13	0.000	.2003357	.5627182
wealth						
2	.1049082	.0710987	1.48	0.140	-.0344426	.244259
3	.1804739	.0793686	2.27	0.023	.0249144	.3360335
4	.3233399	.0893881	3.62	0.000	.1481425	.4985374
5	.2524745	.1109086	2.28	0.023	.0350977	.4698513
2.rur_urb	-.0696844	.0786728	-0.89	0.376	-.2238802	.0845114
_cons	-4.463529	.1572467	-28.39	0.000	-4.771727	-4.155331
