Demography India
Vol. 50, Special Issue (2021), pp. 134-146 ISSN 0970-454X

Relationship between Birth Spacing and Neonatal Deaths and Low Birth Weight in India from 1992 to 2016

William Joe*[1] and Ajay Kumar Verma[2]

Abstract: Reproductive Health and family planning policies and programmes recommend a 3-year period for birth spacing between two succeeding births to improve maternal, infant and child health. Inadequate birth spacing between two successive births increases the risk of neonatal death and adverse health outcomes. This paper examines the relationship between length of birth interval from the preceding birth and its association with neonatal death and low birthweight outcomes. This study uses four rounds of NFHS data and applies multivariate econometric methods to comprehend whether inadequate birth spacing (< 24 months) between two succeeding births has significant risk of neonatal deaths and low birthweight. We also find that confounding factors such as maternal education, sex and birth order of the child, and socioeconomic status of the household are associated with neonatal death and low birth weight outcomes. The study concludes that adverse health outcomes among infants can be averted by improving coverage of reproductive health and family planning services in India.

Keywords: Birth spacing, Family planning, Infant deaths, Low birth weight, Neonatal deaths.

Introduction

Adverse effects of inadequate birth spacing on maternal and child health has been recognized since early 20th Century (Hughes, 1923; Woodbury, 1925). Yerushalmy (1945) was the first national level study in United States that estimated short birth intervals and longer birth intervals were associated with stillbirths. Study based on 26 World Fertility Surveys (Hobcraft et al., 1983) concluded that the effect of births intervals prior to and subsequent to the index child after controlling variables such as prior deaths, maternal age, birth order, and socio-economic status had strong association with infant and early child mortality. Empirical evidence and systematic reviews have consistently noted that both shorter and longer birth intervals are associated with maternal and child mortality and other adverse health outcomes (Conde-Agudelo et al., 2012; Rutstein, 2005; Da Vanzo et al. 2004; Zhu et al., 1999). Findings of these studies were instrumental in policymaking as World Health Organization (WHO) and other national and international organizations have recommended spacing of at least 2-3 years between two succeeding births to improve maternal, infants and child health outcomes (WHO, 2007).

Despite this strong relationship between birth spacing and maternal and child health across the world, there are some recent studies that have raised concerns around the role and relevance of birth spacing for perinatal outcome and infant health. For instance, studies in the high-income countries (Sweden, Canada, and Australia) and low mortality settings has shown that shorter and longer birth intervals were not statistically associated with perinatal health such as birth weight, small gestational age, infant health and risk of preterm birth (Ball et al., 2014;

---

* Corresponding Author
[1] Assistant Professor, Population Research Centre, Institute of Economic Growth, Delhi. Email: william@iegindia.in
[2] PhD Scholar, Department of Economics, Banaras Hindu University, Varanasi. Email: ajaykum.verma@gmail.com

Mignini et al., 2016; Class et al., 2017; Hanley et al., 2017). These studies find that, when adjusted for unobserved residual factors of mother via sibling fixed effects, short birth intervals were not significantly associated with higher risks of low birth weight, being small for gestational age, or preterm birth. However, evidence from low-income countries (South Asia and Sub-Saharan Africa) has shown that birth intervals were significantly associated with infant mortality and morbidity even after adjusting for unobserved confounding factors of the mother (Kravdal, 2018; Kozuki and Walker, 2013).

Birth spacing may be considered as an intervention to improve new-born health and nutritional outcomes, particularly in developing countries (Lassi et al., 2014; Allison et al., 2010). The integration of sexual and reproductive health-care services, including family planning activities, information and education on maternal, new-born, child health, and nutrition services in national strategic and program can positively influence health and wellbeing of women and children (Rana, et al., 2019). However, low birth weight is also a significant determinant of neonatal deaths (O'Leary et al., 2017; Yasmin et al., 2001). The United Nations under SDGs (goals 3) has called for reducing neonatal mortality to at least as low as 12 per 1000 per live births and end all form of malnutrition (goal 2) by 2030 (GA, 2015). However, National Health Policy 2017 of India has set own specific target to reduce neonatal deaths to 16 per thousand birth by 2025. Global estimates for 2017 shows that around 2.5 million newborn die within the first 28 days of birth which leads to a high neonatal mortality rate of 18.0 deaths per 1000 live births (Hug et al., 2019). The mortality rate in India is estimated to be 30 deaths per 1000 live birth whereas the prevalence of low birth weight is 18% in 2015-16 (IIPS and ICF, 2017). According to UN IGME (2018), in 2017, India is estimated to have the highest absolute number of neo-natal deaths (605,000) in the world followed by Pakistan and Nigeria (both 241,000 neonatal deaths). While much of this is because of a large population base but the levels of neonatal mortality rates for India is also high. Given the concerns, policymaking has been advocating and implementing various health and related programs to reduce the magnitude of neonatal deaths in India. Importantly, these programs have limited focus on connecting birth spacing as an instrumental factor causing higher levels of neonatal deaths in the country. Given the relevance, this study uses all four waves of NFHS India (1992-93, 1998-99, 2005-06 and 2015-16) to examine the association of length of birth interval with neonatal deaths and low birth weight outcomes. It may be noted that neonatal mortality is defined as the probability of infants dying within the first month of life (within 28 days). Low birth weight cases are defined as (recorded or reported) birth weight of less than 2.5 kg regardless of gestational age. For analytical purposes, a reference period of three years is used for the sample for neonatal mortality and low birth weight.

Materials and Methods

National Family Health Survey (NFHS) is a nationally representative cross-sectional household survey, conducted by the International Institute for Population Sciences (IIPS) under the stewardship of the Ministry of Health and Family Welfare (MoHFW), Government of India. The first four waves of NFHS has been conducted during the years 1992-93, 1998-99, 2005-06 and 2015-16, respectively. The aim of the NFHS is to provide detailed information on fertility, family planning, infant and child mortality, reproductive health, child health, nutrition of women and children, and the quality of health and family welfare services. NFHS-1 (1992–93) covered a sample of 88,562 households including 89,777 ever-married women (age 15–49 years). NFHS-2 (1998–99) covered a sample of 91,196 households and interviewed 89,199 ever-married women (age 15–49 years). NFHS 3 (2005-06) covers a sample of 109,041 households including124,385 women (age 15-49 years). The NFHS-4 (2015- 16) provides data based on a survey of 601,509 households and 699,686 interviews of women (age 15–49 years). It is worth noting that NFHS 1, 2 and 3 samples were designed to provide state-level estimates whereas NFHS 2015-16 adopted a sample design to provide representative estimates at the district level. Accordingly, the sample size and the sampling power is greater in the NFHS 2015-16 data. Details about survey sampling procedures and questionnaires are available in the reports of NFHS-1, NFHS-2 NFHS-3 and NFHS-4. For brevity, the NFHS adopts a uniform stratified sampling design in each of the NFHS Survey. Two-stage sampling design was used in rural areas where villages were selected in the first stage using probability proportional to size scheme (PPS) and households in the second stage using systematic sampling. In urban areas, a three-stage procedure was adopted. In the first stage, urban wards were selected with PPS sampling. In the next stage, one census enumeration block (CEB) was randomly selected from each sample ward. In the final stage, households were randomly selected within each selected CEB. NFHS-1 provides information on child weight for children under age 48 months, NFHS-2 captures this information for those under 36 months whereas NFHS-3 and NFHS-4 contains this information for children below five years age. In other words, the reference group in terms of age of child and birth weight information varies acrossNFHS-1, NFHS-2 and NFHS-3, NFHS-4. This study, therefore, uses a uniform reference analytical sample of all children under 36 months of age in each NFHS to ensure comparability of estimates. NFHS also provides information on birth history for women which is useful to ascertain information on mortality indicators and birth spacing practices.

Outcome variable

The cases of low birth weight and neonatal deaths are the main outcome variables in this study. NFHS defines children who are below 2.5 kg at the time of birth as low birth weight child. Neonatal death is defined as the infant deaths within the first month of life.

Explanatory variable

The current study has taken birth spacing as a key explanatory variable. Other variables are place of residence (rural or urban areas), maternal age at birth and education, religion, caste, sex of child, place of birth (institutional or home-based), wealth index (five quintiles) and birth order as an explanatory variable in this study. The variables are recoded to facilitate regression analysis. In particular, birth spacing is defined in the following categories: firth birth, < 2 years gap, 2-3 years gap, 3-4 years gap and those born with 4+ years of spacing. Maternal age at birth is recoded in four categories (15-19 years, 20-29 years, 30-39 years, and those age 40 years and above). Maternal education is categorized as follows: those with no formal education, primary education, secondary education and higher secondary and above education. The social group affiliations are defined in terms of three categories: scheduled castes, scheduled tribes and others. Birth order of the child is categorized as first birth, second or third birth, or birth order of 4 and above.

Results

Table 1 shows the distribution of the neonatal deaths per 1000 live birth in India. The neonatal mortality rate among children with birth intervals less than 2 years is estimated to be 82.3, 70.5, 71.9 and 56.9 neonatal deaths per 1000 live births in NFHS-1, NFHS-2, NFHS-3 and NFHS-4 respectively. Children with birth interval of 3 to 4 years had the lowest neonatal mortality rates of 24.4, 22.5, 14.3 and 15.5 per 1000 live birth in NFHS-1, NFHS-2, NFHS-3 and NFHS-4, respectively. Neonatal mortality was higher in rural areas and this was consistently noted for all the four waves of NFHS conducted during 1992-93 to 2015-16. The neonatal mortality rate was lower for births with maternal age at birth between 20 to 29 years

(39.5, 34.9, 33.3 and 27.7 per 1000 live births in NFHS-1, NFHS-2, NFHS-3 and NFHS-4, respectively). Neonatal mortality rates were also low (22.2, 20.7, 18.9 and 18.8 in NFHS-1, NFHS-2, NFHS-3 and NFHS-4, respectively) in case of children born to women with higher secondary and above education. Among scheduled castes (SC) and scheduled tribes (ST) children neonatal mortality rates were higher than other non-SCST households. The neonatal deaths per 1000 live births among male child were 52, 42, 43 and 34 in NFHS-1, NFHS-2, NFHS-3 and NFHS-4 respectively and it was higher than neonatal mortality among females (44, 38, 34 and 27 per 1000 births, respectively). The neonatal mortality rate is estimated to be higher for home-based births (48.9, 39.5, 39.6 and 41.3 per 1000 live birth in NFHS-1, NFHS-2, NFHS-3 and NFHS-4, respectively) than institutional births (37.8, 34.5, 37.0 and 27.3 per 1000 live birth in NFHS-1, NFHS-2, NFHS-3 and NFHS-4, respectively). Among highest wealth quintile households, the neonatal mortality rate was 24.3, 23.5, 24.3 and 15.0 in NFHS-1, NFHS-2, NFHS-3 and NFHS-4, respectively and it was lowest than the other wealth quintiles. Children with birth order 2 or 3 had lower neonatal mortality rate (38.2, 35.4, 29.2 and 25.2 per 1000 live births in NFHS-1, NFHS-2, NFHS-3 and NFHS-4, respectively) than those who are first born or those with higher birth orders.

Table 1: Neonatal mortality rate by demographic and socioeconomic background, India, 1992-2016

Covariate	NFHS-1	NFHS-2	NFHS-3	NFHS-4
Births gap				
< 2 years	82.3	70.5	71.9	56.9
2-3 years	28.7	31.5	29.5	19.9
3-4 years	24.4	22.5	14.3	15.5
4+ years	24.9	23.7	20.7	19.8
first birth	48.2	34.5	34.2	21.3
Place of residence				
Rural	52.2	42.6	42.6	34.3
Urban	33.5	32.9	28.9	19.7
Maternal age at birth				
15-19 years	66.3	54.7	56.4	38.4
20-29 years	39.5	34.9	33.3	27.7
30-39 years	53.0	39.2	42.3	34.8
40 and above years	47.3	61.8	34.0	60.4
Maternal education				
No education	55.5	47.8	46.4	40.5
Primary	38.1	35.1	39.0	34.0
Secondary	31.3	30.6	28.6	22.1
Higher secondary and above	22.2	20.7	18.9	18.8
Caste				
Scheduled caste	58.5	47.8	43.6	34.3
Scheduled tribe	49.1	39.5	37.7	30.6
Others	46.0	38.5	38.0	28.9
Sex of child				
Female	44.2	38.4	34.4	26.7
Male	51.6	42.3	43.4	33.6
Place of Birth				
Institutional	37.8	34.5	37.0	27.3
Home	48.9	39.5	39.6	41.3
Wealth Index				
Poorest	56.8	49.1	47.6	43.6
Poor	58.9	39.7	48.0	34.5
Middle	53.9	48.8	38.9	28.6
Rich	38.2	35.3	28.6	21.2
Richest	24.3	23.5	24.3	15.0
Birth order				
1	62.2	47.2	49.9	32.5
2-3 group	38.2	35.4	29.2	25.2
4+ group	48.4	41.4	42.9	41.4
India	48.0	40.5	39.1	30.3

Source: Authors calculation based on NFHS data

Table 2 reveals the percentage distribution of low birth weight outcomes in India for the various NFHS surveys conducted during 1992-93 to 2015-16. The prevalence of low birth weight among children born with a birth interval of less than 2 years showed a prevalence of 26.3%, 22.7%, 21.4% and 18.7% in NFHS-1, NFHS-2, NFHS-3 and NFHS-4, respectively. In NFHS 1 (1992-93), the low birth weight outcomes in urban areas was higher at 27.4%, while it was higher in rural areas in the following surveys (NFHS-2 23.9%, NFHS-3 24.0% and NFHS-4 18.8%). Maternal age at birth of 15-19 years was associated with prevalence levels of 32.0%, 26.3%, 26.9% and 20.6% in low birth weight outcomes under NFHS-1, NFHS-2, NFHS-3 and NFHS-4, respectively. Women with higher secondary and above level of education had lower prevalence of low birth weight outcomes (21.0%, 16.9%, 16.6% and 15.4% in NFHS-1, NFHS-2, NFHS-3 and NFHS-4, respectively). Prevalence of low birth weight were higher among scheduled castes 27.4%, 26.6% and 25.0% in NFHS-1 NFHS-2, NFHS-3 respectively, and among scheduled tribe prevalence of low birth weight was higher at 20.7% in NFHS-4. Prevalence of low birth weight were lower among male children (25.0%, 21.3%, 20.7% and 17.2% in NFHS-1 NFHS-2, NFHS-3 and NFHS-4, respectively).

Children who had institutional births had a low birth weight prevalence of 26.5%, 22.1%, 22.2% and 18.3% in NFHS-1, NFHS-2, NFHS-3 and NFHS-4, respectively. Among richest quintile the prevalence of low birth weight were 24.8%, 18.8%, 18.7% and 15.4% in NFHS-1, NFHS-2, NFHS-3 and NFHS-4, respectively. Children with birth order 2 or3 had low birthweight prevalence of 24.5%, 22.3%, 21.1% and 17.5% in NFHS-1 NFHS-2, NFHS-3 and NFHS-4, respectively. Noting that in the bivariate analysis in Tables 1 and 2, many factors have been identified as linked to neonatal deaths and low birth weight, including short birth intervals, but it is also necessary to determine whether the importance of birth intervals is significant when these factors are mutually adjusted using multivariate logistic regression analysis.

Table 3 reports the results from the multivariate logistic regression to discern the association of birth spacing and other covariates with neonatal deaths. Birth intervals less than 2 years between two successive live births were found to be significantly associated with an elevated risk of death within first month of life as compared with birth intervals of 3-4 years. This finding is consistent across all the four waves of the NFHS. The odds ratio (OR) of neonatal deaths for the case of birth spacing of less than two years is as follows: NFHS-1 OR: 3.35, 95% CI 2.61 -4.30), (NFHS-2 OR: 3.11, 95% CI 2.37- 4.08), (NFHS-3 OR: 4.53, 95% CI 3.07-6.68) and (NFHS-4 OR: 3.25, 95% CI 2.74-3.86). Children born in urban areas have lower risk of neonatal death as compared to children from rural areas (OR: 0.80, 95% CI 0.71-0.91) in NFHS-4. The odds ratio associated with the children born at maternal age of 20-29 years is also significantly low. This suggests that the likelihood of children dying in the first month of life is related with mother's age at child birth with adverse risks particularly for teenage mothers.

Illiteracy among mothers is a major underlying factor of neonatal death as children are more likely to succumb within the first month of life when compared to mothers with higher secondary education. The associated odds for the various survey years are as follows: OR: 1. 80 (95% CI 1.20-2.70), OR: 2.04 (95% CI 1.33-3.13), OR: 2. 18 (95% CI 1.41-3.38), and OR: 1.44, (95% CI 1.23-1.69) in NFHS-1 NFHS-2, NFHS-3 and NFHS-4, respectively. Children from SC community were more likely to die within the four weeks after birth as compared to non-SC / non-ST social groups (OR: 1.20, 95% CI 1.00-1.43) in NFHS-1. Male children had higher probability of neonatal death compared to female children (OR: 1.19, 95% CI 1.05-1.36), (OR: 1.35, 95% CI 1.15-1.59) and (OR: 1.30, 95% CI 1.20-1.40) in NFHS-1, NFHS-3 and NFHS-4, respectively. Children who were born at home were less likely to die in first month of life (OR: 0.78, 95% CI 0.64-0.94) in NFHS-3 and more likely to die in first month in life in NFHS 4 (OR: 1.20, 95% CI 1.09-1.33) as compared to children who born in any health facility. Children belonging to households from lowest wealth quintile were more likely to die in first month of life as compared with those from households in highest wealth quintile (OR: 1.90, 95% CI 1.39-2.59), (OR: 1.55, 95% CI 1.12-2.16), (OR: 1.64, 95% CI 1.09-2.46) and (OR: 1.76, 95% CI 1.43-2.15) in NFHS-1 NFHS-2, NFHS-3 and NFHS-4, respectively. Children with birth order 2-3 were less likely to die in first month of life as compared those who are first born (OR: 0.38, 95% CI 0.30-0.48), (OR: 0.47, 95% CI 0.36,0.61), (OR: 0.33, 95% CI 0.25-0.42) and (OR: 0.33, 95% CI 0.29-0.38) in NFHS-1 NFHS-2, NFHS-3 and NFHS-4, respectively.

Table 2: Prevalence of low birth weight outcomes by demographic and socioeconomic background, India (1992-2016)

Covariate	**NFHS-1**	**NFHS-2**	**NFHS-3**	**NFHS-4**
Births gap	(%)	(%)	(%)	(%)
< 2 years	26.39	22.73	21.42	18.7
2-3 years	26.91	19.71	22.18	16.88
3-4 years	22.92	21.52	20.37	16.27
4+ years	19.98	22.02	18.07	16.47
first birth	28.03	22.54	22.72	18.52
Place of residence				
Rural	25.19	23.94	24.09	18.83
Urban	27.41	21.06	20.47	17.76
Maternal age at birth				
15-19 years	32.04	26.31	26.97	20.62
20-29 years	25.24	21.81	21.81	18.12
30-39 years	24.75	19.56	19.31	18.21
40 and above years	7.83	37.48	12.9	25.4
Maternal education				
No education	28.91	29.97	27.32	20.68
Primary	30.2	23.77	24.8	19.97
Secondary	25.25	20.45	21.19	17.85
Higher secondary and above	21.01	16.98	16.62	15.44
Caste				
Scheduled caste	27.46	26.67	25	19.21
Scheduled tribe	24.33	25.33	22.61	20.78
Others	26.51	21.7	21.94	17.94
Sex of child				
Female	28	24.07	24.54	19.84
Male	25.08	21.36	20.77	17.29
Place of Birth				
Institutional	26.52	22.15	22.21	18.35
Home	26.54	28.44	24.55	20.6
Wealth Index				
Poorest	21.59	28.51	26.12	20.47
Poor	30.59	26.59	27.31	19.36
Middle	29.1	25.84	23.85	18.71
Rich	28.03	22.79	22.39	18.21
Richest	24.89	18.87	18.77	15.42
Birth order				
1	28.71	22.63	23.1	19.18
2-3 group	24.52	22.29	21.15	17.58
4+ group	25.82	24.2	26.24	20.02
India	26.49	22.64	22.51	18.5

Source: Authors calculation based on NFHS data

Table 3: Multivariate logistic regression based association of demographic and socioeconomic factors with neonatal deaths, India 1992-2016

Covariate	**NFHS-1**	**NFHS-2**	**NFHS-3**	**NFHS-4**
Births gap	**OR [95% CI]**	**OR [95% CI]**	**OR [95% CI]**	**OR [95% CI]**
< 2 years	3.35*** [2.61,4.30]	3.11*** [2.37,4.08]	4.53*** [3.07,6.68]	3.25*** [2.74,3.86]
2-3 years	1.11 [0.85,1.46]	1.48*** [1.11,1.96]	1.91*** [1.28,2.86]	1.19* [0.99,1.44]
3-4 years®	1	1	1	1
4+ years	0.99 [0.73,1.35]	1.02 [0.73,1.44]	1.47* [0.93,2.33]	1.28** [1.04,1.57]
first birth	0.90 [0.65,1.25]	0.88 [0.61,1.27]	0.96 [0.60,1.52]	0.65*** [0.52,0.80]
Place of residence				
Rural®	1	1	1	1
Urban	0.86 [0.70,1.05]	0.90 [0.73,1.11]	0.87 [0.70,1.07]	0.80*** [0.71,0.91]
Maternal age at birth				
15-19 years®	1	1	1	1
20-29 years	0.84** [0.71,1.00]	0.79** [0.66,0.95]	0.86 [0.69,1.06]	0.94 [0.84,1.06]
30-39 years	1.22 [0.93,1.59]	0.95 [0.70,1.30]	1.14 [0.81,1.60]	1.31*** [1.10,1.56]
40 and above years	1.16 [0.62,2.18]	1.55 [0.80,3.00]	0.92 [0.38,2.25]	1.90*** [1.36,2.66]
Maternal education				
No education	1.80*** [1.20,2.70]	2.04*** [1.33,3.13]	2.18*** [1.41,3.38]	1.44*** [1.23,1.69]
Primary	1.27 [0.85,1.89]	1.38 [0.91,2.09]	1.76** [1.14,2.71]	1.41*** [1.22,1.65]
Secondary	1.25 [0.79,1.97]	1.36 [0.87,2.14]	1.31 [0.85,2.01]	0.99 [0.84,1.16]
Higher secondary and above®	1	1	1	1
Caste				
Scheduled caste	1.20** [1.00,1.43]	1.13 [0.95,1.34]	1.05 [0.86,1.28]	1.04 [0.95,1.14]
Scheduled tribe	0.92 [0.74,1.15]	0.92 [0.73,1.17]	0.85 [0.65,1.12]	0.82*** [0.72,0.93]
Others®	1	1	1	1
Sex of child				
Female®	1	1	1	1
Male	1.19*** [1.05,1.36]	1.09 [0.95,1.26]	1.35*** [1.15,1.59]	1.30*** [1.20,1.40]
Place of Birth				
Institutional®	1	1	1	1
Home	0.95 [0.79,1.14]	0.92 [0.76,1.11]	0.78** [0.64,0.94]	1.20*** [1.09,1.33]
Wealth Index				
Poorest	1.90*** [1.39,2.59]	1.55*** [1.12,2.16]	1.64** [1.09,2.46]	1.76*** [1.43,2.15]
Poor	1.70*** [1.25,2.30]	1.21 [0.87,1.68]	1.49** [1.01,2.21]	1.48*** [1.22,1.79]
Middle	1.71*** [1.27,2.29]	1.58*** [1.16,2.15]	1.28 [0.88,1.88]	1.36*** [1.12,1.66]
Rich	1.28* [0.97,1.70]	1.23 [0.91,1.64]	0.99 [0.69,1.42]	1.09 [0.90,1.33]
Richest®	1	1	1	1
Birth order				
1®	1	1	1	1
2-3 group	0.38*** [0.30,0.48]	0.47*** [0.36,0.61]	0.33*** [0.25,0.42]	0.33*** [0.29,0.38]
4+ group	0.40*** [0.31,0.53]	0.49*** [0.36,0.68]	0.38*** [0.27,0.52]	0.37*** [0.32,0.44]
Number	**34869**	**31583**	**29369**	**148854**

Note- P <0.01***, P <0.05** and *<0.10, ® = Reference

Table 4 reports the results from the multivariate logistic regression to discern the association of birth spacing and other covariates with low birth weight outcomes. Birth intervals of less than 2 years between two successive live birth displayed greater risks for experiencing low birth weight outcomes as compared to optimal birth intervals of 3-4 years between two successive live births (OR: 1.13, 95% CI 0. 1.02-1.25 in 2015-16).

Table 4: Multivariate logistic regression based association of demographic and socioeconomic factors with low birth weight outcomes, India 1992-2016

Covariate	**NFHS-1**	**NFHS-2**	**NFHS-3**	**NFHS-4**
Births gap	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
< 2 years	1.09 [0.81,1.49]	1.08 [0.83,1.39]	1.01 [0.79,1.29]	1.13** [1.02,1.25]
2-3 years	1.14 [0.84,1.55]	0.87 [0.67,1.12]	1.06 [0.84,1.35]	1.01 [0.92,1.12]
3-4 years®	1	1	1	1
4+ years	0.83 [0.60,1.16]	1.07 [0.82,1.40]	0.93 [0.72,1.20]	1.03 [0.93,1.14]
first birth	1.00 [0.66,1.53]	1.20 [0.84,1.72]	1.18 [0.85,1.64]	1.05 [0.92,1.19]
Place of residence				
Rural®	1	1	1	1
Urban	1.28*** [1.08,1.53]	1.03 [0.90,1.19]	0.93 [0.82,1.06]	1.06* [0.99,1.13]
Maternal age at birth				
15-19 years®	1	1	1	1
20-29 years	0.84 [0.69,1.03]	0.90 [0.75,1.07]	0.86* [0.74,1.01]	0.96 [0.89,1.02]
30-39 years	1.00 [0.72,1.39]	0.84 [0.63,1.13]	0.75** [0.58,0.98]	0.99 [0.90,1.10]
40 and above years	0.25** [0.06,0.97]	2.04 [0.77,5.44]	0.44 [0.15,1.29]	1.30* [0.99,1.70]
Maternal education				
No education	1.56*** [1.16,2.09]	1.83*** [1.43,2.34]	1.84*** [1.48,2.29]	1.44*** [1.33,1.56]
Primary	1.66*** [1.33,2.07]	1.41*** [1.15,1.73]	1.63*** [1.36,1.96]	1.37*** [1.28,1.48]
Secondary	1.27** [1.02,1.59]	1.22* [1.00,1.49]	1.35*** [1.13,1.62]	1.17*** [1.09,1.26]
Higher secondary and above®	1	1	1	1
Caste				
Scheduled caste	0.92 [0.67,1.25]	1.16 [0.97,1.39]	1.08 [0.92,1.26]	1.05* [1.00,1.11]
Scheduled tribe	0.93 [0.63,1.39]	1.08 [0.81,1.44]	0.86 [0.68,1.09]	1.11*** [1.04,1.19]
Others®	1	1	1	1
Sex of child				
Female®	1	1	1	1
Male	0.84** [0.72,0.97]	0.85** [0.75,0.97]	0.80*** [0.71,0.90]	0.84*** [0.80,0.88]
Place of Birth				
Institutional®	1	1	1	1
Home	0.91 [0.65,1.28]	1.24* [0.99,1.57]	1.04 [0.86,1.24]	1.11** [1.02,1.21]
Wealth Index				
Poorest	0.67 [0.39,1.15]	1.18 [0.86,1.63]	1.05 [0.80,1.38]	1.18*** [1.07,1.30]
Poor	1.24 [0.87,1.75]	1.09 [0.83,1.42]	1.12 [0.89,1.41]	1.16*** [1.06,1.27]
Middle	1.06 [0.80,1.40]	1.14 [0.91,1.43]	1.00 [0.82,1.21]	1.16*** [1.06,1.27]
Rich	1.12 [0.92,1.36]	1.08 [0.91,1.28]	1.04 [0.89,1.23]	1.16*** [1.06,1.26]
Richest®	1	1	1	1
Birth order				
1®	1	1	1	1
2-3 group	0.78 [0.56,1.09]	1.11 [0.83,1.49]	0.98 [0.76,1.27]	0.82*** [0.75,0.90]
4+ group	0.72 [0.48,1.09]	1.02 [0.72,1.45]	1.09 [0.79,1.50]	0.83*** [0.74,0.93]
Number	6065	8491	12780	116110

Note- P <0.01***, P <0.05** and *<0.10, ® = Reference

Nevertheless, it may be noted that the association of short birth intervals with low birth weight outcomes finds low level of magnitude and significance when compared to the association with neonatal mortality. The effect here is found to be significant with increased sample size as available via NFHS-4 whereas the odds ratio (although above 1) remains statistically insignificant for previous rounds of NFHS. Among other factors, children from urban sector were more likely to have low birth weight as compared to children from rural background. The adverse urban effect is particularly significant for NFHS-1 (OR: 1.28, 95% CI 1.08-1.53) and NFHS-4 (OR: 1.06, 95% CI 0.99-1.13) in. Maternal age at birth of 20 and 29 years displayed lower tendency for low birth weight outcomes as compared with child birth for other maternal age groups (OR: 0.86, 95% CI 0.74-1.01) in NFHS-3. Similar to the case of neonatal mortality, illiterate mothers faced increased odds of low birth weight outcomes compared to educated mothers. Compared to educated mothers, the odds ratio for illiterate mothers is estimated to be (OR: 1.56, 95% CI 1.16-2.09), (OR: 1.83, 95% CI 1.43-2.34), (OR: 1.84, 95% CI 1.48-2.29) and (OR: 1.44, 95% CI 1.33-1.56) in NFHS-1 NFHS-2, NFHS-3 and NFHS-4, respectively. Children from ST community were more likely to have low birth weight as compared with children from other non-SC or non-ST background (OR: 1.11, 95% CI 1.04-1.19) in NFHS-4. Male children were less likely to have low birth weight as compare with female children (OR: 0.84, 95% CI 0.72-0.97), (OR: 0.85, 95% CI 0.75-0.97), (OR: 0.80, 95% CI 0.71-0.90) and (OR: 0.84, 95% CI 0.80-0.88) in NFHS-1 NFHS-2, NFHS-3 and NFHS-4 respectively. Home based births were more likely to be low birth weight cases than institutional births (OR: 1.24, 95% CI 0.99-1.57) and (OR: 1.11, 95% CI 1.02-1.21) in NFHS-2 and NFHS-4 respectively. Among poorest households, children were more likely to have low birth weight than those from better-off households (OR: 1.18, 95% CI 1.07-1.30) in NFHS-4. It is also important to note that children with birth order 2-3 were less likely to have low birth weight than those who are first born (OR: 0.82, 95% CI 0.75-0.90) in NFHS-4.

Discussion

The present study uses all four waves of NFHS and emerges with four key findings regarding the association between birth spacing in India and its significant influence on low birth weight outcomes and neonatal deaths in India. First, low birth spacing length is associated with an elevated risk of both neonatal deaths as well as higher prevalence of low birth weight outcomes. Second, maternal education is also significantly associated with neonatal deaths and low birth weight prevalence. Third, household socioeconomic status (wealth index as a proxy) has an influential role in reducing the risks of neonatal death and low birth weight among new-born. Fourth, sex of the child and the birth order also plays a significant role in influencing neonatal deaths and low birth weight outcomes. The study, however, has a few limitations as follows. First, the study uses analytical sample of children who are born three years before the NFHS survey. Second, the analysis excludes the sample of twin births. Third, we could not address for various unobserved maternal factors that may be associated with neonatal deaths and low birth weight outcomes such as the clinical status of mothers and her dietary and awareness levels and practices. Finally, the study uses cross-sectional data hence we cannot attribute causality in relationship between birth spacing and the two outcome variables of neonatal deaths and low birth weight outcomes.

Study outcomes suggests that short birth spacing (<24 months) is significantly associated with risk of infant deaths within first month of life during 1992-93, 1998-99, 2005-06 and 2015-16. Nevertheless, association between birth spacing and low birth weight were not statistically significant for all the survey years, except in 2015-16. This may be because the effects are lower and could be captured with adequate sample size. Also, we noted that the odds were higher even for the previous survey years. This finding is consistent with previous evidence (Monawar Hosain et al., 2005) that also shows that there was no association between birth spacing and low birth weight. It is noted that that birth spacing with high parity among women is more likely to be associated with low birth weight, instead of birth spacing only (Merklinger-Gruchala, 2015).

The findings of the study are consistent with previous empirical research work in developing countries (Kravdal, 2018; Kozuki and Walker, 2013**).** Previously, Whitworth and Stephenson (2002) had noted that the length of the preceding birth interval has significant impact on under-two mortality in India. This study also confirms it as a pathway through which short preceding birth intervals may lead to an increased risk of mortality. Another study (Rana et al., 2019) found that higher birth order and low birth intervals were significantly associated with child stunting, underweight, anaemia and mortality in India. Evidence shows that maternal nutritional depletion due to shorter birth intervals as well as transmission of infectious disease from older sibling to younger sibling could also be the possible reasons for poor child health outcomes (Conde-Agudelo et al., 2012). Theory of maternal nutritional depletion also suggests that short births intervals may affect maternal nutritional requirements to maintain physiological and foetal development (King, 2003). It is noted that during pregnancy the nutritional requirements of women increases substantially (for instance, energy needs goes up by 13% with specific demand for protein diet that goes up by 54%and that for micronutrients increasing by up to 50%, depending on the vitamin or mineral in question (Dewey and Cohen, 2007). Secondly, it is argued that sibling competition may be associated with adverse outcomes of infant particularly in the context of developing countries. Sibling competition may include competition for parental time or material resources among closely spaced siblings and in such cases this may lead to reduced time for self-care and nutrition during pregnancy (Ramachandran, 2002; Molitoris et al., 2019). Third and final mechanism is the disease transmission that may be linked with inadequate birth intervals to infant deaths. Studies have noted that inadequate birth intervals could increase the risk of worm infestation, respiratory infection, and gastroenteritis (Miller, 1991; Bøhler and Bergström, 1995; Conde-Agudelo et al., 2012).

Findings of this study reveals that illiterate mother and low level of education are associated with higher neonatal deaths and low birth weight during 1992-93, 1998-99, 2005-06 and 2015-16. Maternal education plays an important role in infant survival in developing countries. The findings of this study are thus consistently supported by previous studies that shows that low level of maternal education have significant association with the neonatal deaths and low birth weight (Kamal, 2012; Silvestrin et al., 2013; Fonseca et al., 2017). Earlier studies suggested many pathways of maternal education that determined infant health. For instance, Vikram and Vanneman (2020) reveals that educated mothers are more likely have better access and uptake of medical services than illiterate or less educated ones (Hobcraft, 1993). Outcomes of the present study shows that gender of the child and birth order are important determinant of neonatal mortality during 1992-93 to 2015-16. Finding reveals that male child is less likely to have low birth weight as compared to girls but male child have a higher risk of neonatal mortality. We, however, do not found any previous research work that addresses the causal relationship between neonatal deaths and low birth weight with gender of child in India. Our study thus suggests the need for further research on understanding the association between low birth weight and neonatal mortality with respect to sex of the child. In this regard, previous studies have also suggested risk of neonatal mortality being higher among male child in India (Shil et al., 2016; Kumar et al., 2013; Mekonnen et al., 2013). The earlier studies also confirm the finding that first born children have higher risk of neonatal death compared with 2-3 birth order in India (Quamrul et al., 2010).

The outcomes of present study showed strong association between household wealth status with neonatal mortality in NFHS-1, NFHS-2 NFHS-3 and NFHS-4 and with low birth weight in NFHS-4. This is a consistent relationship observed by various other studies that poorest households have more prevalence of neonatal death than richer households (McKinnon et al., 2014; Mohanty, 2011). It is plausible that poor may be unable to meet their nutrition requirements, access health services, and live in quality household environment. All these factors, jointly are expected to have an adverse effect on neonatal deaths and low birth weight outcomes (Yaya et al., 2014; Lartey et al., 2011).

Conclusion

Inadequate birth intervals (below 2-3 years) adversely affects neonatal mortality and influences low birth weight prevalence in India. It is important that adequate birth spacing is practiced and promoted through reproductive health and family planning programmes to improve child health outcomes, especially in developing countries like India. Other factors such as maternal education, sex of the child, birth order, and socioeconomic status of household were associated with neonatal deaths and low birth weight outcomes. The incidence of neonatal deaths and low birth weight outcomes may be averted by providing adequate level of reproductive health and family planning services in India. We suggest that policymakers from the union and the state governments, health administrators, development partners and stakeholders including the private health sector increasingly contribute toward improving birth spacing practices through various reproductive health and family planning activities.

Acknowledgment

The present study is fully independent and not received any financial support from the any institution and organization. Authors have full accountability of this analysis.

References

Allison, A., Anthony-Kouyate, R., Blanchard, H., Deller, B., Foreman, M., and Galloway, R., 2010, Maximizing synergy between maternal, infant and young nutrition and pregnancy prevention: a discussion paper prepared for maternal, infant and young child nutrition (MIYCN) and family planning (FP) integration technical meeting. 2010.

Ball, S. J., Pereira, G., Jacoby, P., De Klerk, N., and Stanley, F. J., 2014, Re-evaluation of link between interpregnancy interval and adverse birth outcomes: retrospective cohort study matching two intervals per mother. *BMJ*, *349*: g4333.

Bøhler, E., and Bergström, S., 1995, Subsequent pregnancy affects morbidity of previous child. *Journal of biosocial science*, *27*(4): 431-442.

Class, Q. A., Rickert, M. E., Oberg, A. S., Sujan, A. C., Almqvist, C., Larsson, H., ... and D'Onofrio, B. M., 2017, Within-family analysis of interpregnancy interval and adverse birth outcomes. *Obstetrics and Gynecology*, *130*(6): 1304.

Conde-Agudelo, A., Rosas-Bermudez, A., Castaño, F., and Norton, M. H., 2012, Effects of birth spacing on maternal, perinatal, infant, and child health: a systematic review of causal mechanisms. *Studies in Family Planning*, *43*(2): 93-114.

DaVanzo, J., Razzaque, A., Rahman, M., Hale, L., Ahmed, K., Khan, M. A., ... and Gausia, K., 2004, The effects of birth spacing on infant and child mortality, pregnancy outcomes, and maternal morbidity and mortality in Matlab, Bangladesh. *Technical Consultation and Review of the Scientific Evidence for Birth Spacing*.

Dewey, K. G., and Cohen, R. J., 2007, Does birth spacing affect maternal or child nutritional status? A systematic literature review. *Maternal and Child Nutrition*, *3*(3): 151-173.

Fonseca, S. C., Flores, P. V. G., Camargo Jr, K. R., Pinheiro, R. S., and Coeli, C. M., 2017, Maternal education and age: inequalities in neonatal death. *Revista de Saude Publica*, *51*, 94.

GA, U., 2015, Transforming our world: the 2030 Agenda for Sustainable Development. *Division for Sustainable Development Goals: New York, NY, USA*.

Hanley, G. E., Hutcheon, J. A., Kinniburgh, B. A., and Lee, L., 2017 Interpregnancy interval and adverse pregnancy outcomes. *Obstetrics and Gynecology*, *129*(3): 408-415.

Hobcraft, J., 1993, Women's education, child welfare and child survival: a review of the evidence. *Health Transition Review*, 159-175.
Hobcraft, J., McDonald, J. W., and Rutstein, S., 1983, Child-spacing effects on infant and early child mortality. *Population Index*, 585-618.
Hug, L., Alexander, M., You, D., Alkema, L., and for Child, U. I. A. G. (2019). National, regional, and global levels and trends in neonatal mortality between 1990 and 2017, with scenario-based projections to 2030: a systematic analysis. *The Lancet Global Health*, 7(6), e710-e720.
Hughes, E., 1923, Inf'ant Mortality. Results of a Field Study in Gary, India, Based on Births in One Year. Children's Bureau Publication, No. 112. Washington, D.C.: U.S. Govt. Printing Office.
IIPS and ICF., 2017, National Family Health Survey (NFHS-4), 2015–16. International Institute for Population Sciences (IIPS), Mumbai, India, 791-846.
Kamal, S. M., 2012, Maternal education as a determinant of neonatal mortality in Bangladesh. *Journal of Health Management*, *14*(3): 269-281.
King, J. C., 2003, The risk of maternal nutritional depletion and poor outcomes increases in early or closely spaced pregnancies. *The Journal of Nutrition*, 133(5), 1732S-1736S.
Kozuki, N., and Walker, N., 2013, Exploring the association between short/long preceding birth intervals and child mortality: using reference birth interval children of the same mother as comparison. *BMC Public Health*, *13*(S3): S6.
Kravdal, Ø., 2018, New evidence about effects of reproductive variables on child mortality in sub-Saharan Africa. *Population Studies*, *72*(2): 139-156.
Kumar, C., Singh, P. K., Rai, R. K., and Singh, L., 2013, Early neonatal mortality in India, 1990–2006. *Journal Of Community Health*, 38(1), 120-130.
Lartey, S. T., Khanam, R., and Takahashi, S., 2016, The impact of household wealth on child survival in Ghana. *Journal of Health, Population and Nutrition, 35*(1): 38.
Lassi, Z. S., Mansoor, T., Salam, R. A., Das, J. K., and Bhutta, Z. A., 2014, Essential pre-pregnancy and pregnancy interventions for improved maternal, newborn and child health. *Reproductive Health*, 11(1), 1-19.
McKinnon, B., Harper, S., Kaufman, J. S., and Bergevin, Y., 2014, Socioeconomic inequality in neonatal mortality in countries of low and middle income: a multicountry analysis. *The Lancet Global Health*, *2*(3): e165-e173.
Mekonnen, Y., Tensou, B., Telake, D. S., Degefie, T., and Bekele, A., 2013, Neonatal mortality in Ethiopia: trends and determinants. *BMC Public Health*, 13(1), 1-14.
Merklinger-Gruchala, A., Jasienska, G., and Kapiszewska, M., 2015, Short interpregnancy interval and low birth weight: A role of parity. *American Journal of Human Biology*, 27(5), 660-666.
Mignini, L. E., Carroli, G., Betran, A. P., Fescina, R., Cuesta, C., Campodonico, L., ... and Khan, K. S., 2016, Interpregnancy interval and perinatal outcomes across Latin America from 1990 to 2009: a large multi-country study. *BJOG: An International Journal of Obstetrics and Gynaecology*, *123*(5): 730-737.
Miller, J. E., 1991, Birth intervals and perinatal health: an investigation of three hypotheses. *Family Planning Perspectives*, 62-70.
Mohanty, S. K., 2011, Multidimensional poverty and child survival in India. *Plos One*, *6*(10): e26857.
Molitoris, J., Barclay, K., and Kolk, M., 2019, When and where birth spacing matters for child survival: an international comparison using the DHS. *Demography*, *56*(4): 1349-1370.
Monawar Hosain, G. M., Chatterjee, N., Begum, A., and Saha, S. C., 2005, Factors associated with low birthweight in rural Bangladesh. *Journal of Tropical Pediatrics*, 52(2), 87-91.

O'Leary, M., Edmond, K., Floyd, S., Newton, S., Thomas, G., and Thomas, S. L. (2017). A cohort study of low birth weight and health outcomes in the first year of life, Ghana. *Bulletin of the World Health Organization*, 95(8), 574.

Quamrul, H. C., Islam, R., and Hossain, K., 2010, Effects of demographic characteristics on neonatal, post neonatal, infant and child mortality. *Journal of Biosocial Sciences Biol Sci*, *2*: 132-138.

Ramachandran, P., 2002, Maternal nutrition—effect on fetal growth and outcome of pregnancy. *Nutrition Reviews*, *60*(suppl_5): S26-S34.

Rana, M. J., Gautam, A., Goli, S., Reja, T., Nanda, P., Datta, N., and Verma, R., 2019, Planning of births and maternal, child health, and nutritional outcomes: recent evidence from India. *Public Health*, 169, 14-25.

Rutstein, S. O., 2005, Effects of preceding birth intervals on neonatal, infant and under-five years mortality and nutritional status in developing countries: evidence from the demographic and health surveys. *International Journal of Gynecology and Obstetrics*, 89, S7-S24.

Shil, A., Puri, P., Mishra, A., and Mishra, R. N., 2016, Determinants of infant mortality in India. *International Journal of Health Sciences and Research*, 6(2), 15-23.

Silvestrin, S., da Silva, C. H., Hirakata, V. N., Goldani, A. A., Silveira, P. P., and Goldani, M. Z., 2013, Maternal education level and low birth weight: a meta-analysis. *Jornal de Pediatria (Versão em Português)*, *89*(4): 339-345.

United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), 2018, 'Levels and Trends in Child Mortality: Report 2018, Estimates developed by the United Nations Inter-agency Group for Child Mortality Estimation', United Nations Children's Fund, New York.

Vikram, K., and Vanneman, R., 2020, Maternal education and the multidimensionality of child health outcomes in India. *Journal of Biosocial Science*, *52*(1): 57.

Whitworth, A., and Stephenson, R. (2002). Birth spacing, sibling rivalry and child mortality in India. *Social Science and Medicine*, 55(12), 2107-2119.

Woodbury, R. M., 1925, *Causal factors in infant mortality: a statistical study based on investigations in eight cities* (No. 142). US Government Printing Office.

World Health Organization., 2007, *Report of a WHO technical consultation on birth spacing: Geneva, Switzerland 13-15 June 2005* (No. WHO/RHR/07.1). World Health Organization.

Yasmin, S., Osrin, D., Paul, E., and Costello, A., 2001, Neonatal mortality of low-birth-weight infants in Bangladesh. *Bulletin of the World Health Organization*, *79*: 608-614.

Yaya, Y., Eide, K. T., Norheim, O. F., and Lindtjørn, B., 2014, Maternal and neonatal mortality in south-west Ethiopia: estimates and socio-economic inequality. *PloS One*, *9*(4): e96294.

Yerushalmy, J., 1945, On the Interval Between Successive Births and its Effect on Survival of Infant An Indirect Method of Study. *Human Biology*, *17*(2): 65-106.

Zhu, B. P., Rolfs, R. T., Nangle, B. E., and Horan, J. M., 1999, Effect of the interval between pregnancies on perinatal outcomes. *New England Journal of Medicine*, *340*(8): 589-594.