

Original Article

Association Between Daughter-Driven Short Birth Interval and Adverse Maternal and Child Health Outcomes: A Case–Control Study

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ABSTRACT

Background: Short birth interval is associated with adverse maternal and child health outcomes, but limited evidence from Pakistan has examined whether short spacing after daughters and linked with son preference carries additional clinical risk. **Objective:** To determine the association between daughter-driven short birth interval and adverse maternal and child health outcomes among parous women receiving obstetric care in Karachi, Pakistan. **Methods:** A hospital-based comparative analytical study was conducted among 364 women, including 182 women with daughter-driven short birth interval and 182 women with optimal birth spacing. Daughter-driven short birth interval was defined as a birth-to-birth interval of less than 24 months after one or more daughters with self-reported desire or family pressure for a son. Maternal and child outcomes were verified through structured interviews and medical records. Crude and odds ratios were calculated using logistic regression, adjusting for age, parity, education, contraception use, and antenatal care utilization. **Results:** Maternal anemia was more frequent in the daughter-driven short birth interval group than in the optimal-spacing group (64.8% vs. 22.0%; aOR = 4.21, 95% CI 2.38–7.45). Low birth weight (58.2% vs. 14.8%; aOR = 6.12, 95% CI 3.28–11.42) and preterm birth (50.5% vs. 12.1%; aOR = 5.84, 95% CI 2.95–11.55) were also significantly associated with daughter-driven short birth interval. Neonatal death was higher in crude analysis but not significant after adjustment (aOR = 1.92, 95% CI 0.85–4.35). **Conclusion:** Daughter-driven short birth interval was strongly associated with maternal anemia, low birth weight, and preterm birth, supporting the need for gender-sensitive birth-spacing counseling, contraception access, anemia prevention, and postpartum maternal recovery services. **Keywords:** short birth interval, daughter-driven fertility, son preference, maternal anemia, low birth weight, preterm birth, neonatal death, birth spacing.

INTRODUCTION

Short birth interval remains an important and modifiable determinant of maternal and child morbidity in low- and middle-income countries, where repeated pregnancies often occur in settings of nutritional vulnerability, limited contraceptive autonomy, and unequal access to antenatal and postnatal care. The World Health Organization recommends adequate spacing after a live birth to allow maternal physiological recovery and to reduce the risk of adverse pregnancy and newborn outcomes, particularly among women with repeated pregnancies and limited access to health services (1). In Pakistan, short birth intervals continue to contribute substantially to reproductive and perinatal risk, with population-based and hospital-based evidence showing that pregnancies occurring after insufficient spacing are

associated with maternal anemia, preterm birth, low birth weight, neonatal morbidity, and perinatal mortality (2,3). These risks are biologically plausible because closely spaced pregnancies may limit restoration of maternal micronutrient reserves, impair recovery from the preceding pregnancy and lactation period, and increase susceptibility to placental, hypertensive, hemorrhagic, and fetal growth-related complications (4).

The burden of short birth interval in Pakistan is not only biomedical but also sociocultural. Reproductive decision-making is shaped by gender norms, family expectations, contraceptive access, and son preference, all of which may influence whether couples delay or accelerate the next pregnancy. Previous Pakistani evidence indicates that women with no sons or with previous daughters are more likely to continue childbearing and less likely to adopt modern contraception, suggesting that gender composition of existing children can alter parity progression and spacing behavior (5). This pattern is consistent with earlier work from Pakistan showing that son preference affects fertility intentions, contraceptive use, and reproductive continuation, particularly among women whose previous children are daughters (6,7). In such settings, a pregnancy occurring shortly after the birth of a daughter may represent not merely a short interval but a gender-driven reproductive response, in which social pressure to have a son accelerates conception before maternal recovery is complete.

Short birth intervals and son preference have each been studied separately, but their combined effect remains insufficiently examined. Existing literature has established that shorter interpregnancy or birth-to-birth intervals are associated with adverse fetal and neonatal outcomes, including low birth weight, preterm birth, neonatal death, and increased neonatal care needs (2,3,8). Other studies have shown that maternal anemia is highly prevalent in Pakistan and is associated with adverse perinatal outcomes, especially when compounded by closely spaced pregnancies and poor antenatal care utilization (9,10). However, limited evidence has directly evaluated whether short intervals specifically occurring after the birth of daughters and motivated by son preference are associated with a higher burden of maternal and child health complications. This distinction is important because daughter-driven short birth interval may identify a subgroup of women exposed to overlapping biological depletion, high parity, reduced contraceptive autonomy, and gender-based reproductive pressure.

The present study was therefore designed to examine the association between daughter-driven short birth interval and adverse maternal and child health outcomes among parous women receiving obstetric care in Karachi, Pakistan. The study followed an exposure-defined comparative analytical approach in which women with daughter-driven short birth interval were compared with women who had optimal birth spacing, rather than defining groups by the presence or absence of adverse outcomes. This approach avoids circular classification and allows maternal and child outcomes to be assessed as dependent variables. The primary hypothesis was that daughter-driven short birth interval would be associated with higher odds of maternal anemia, low birth weight, and preterm birth after adjustment for age, parity, education, residence, contraception use, and antenatal care utilization. The study further explored whether these associations differed by residence and parity, given the potential influence of healthcare access and cumulative reproductive burden on maternal and newborn risk.

MATERIAL AND METHODS

This hospital-based comparative analytical study was conducted among parous women receiving obstetric and postnatal care at selected public and private hospitals in Karachi, Pakistan, including Jinnah Postgraduate Medical Centre, Civil Hospital Karachi, KMC Maternity Hospital Gizri, Sindh Government Hospital Liaquatabad, Raf-e-Aam Medical Centre Karachi, Saiffee Hospital, and Sindh Government Hospital Thado Nalo. The study was designed to compare maternal and child health outcomes between women exposed to daughter-driven short birth interval and women with optimal birth spacing. To address the methodological concern of circular case definition, group allocation was based on exposure status rather than on the presence of adverse outcomes. Women in the exposed group were those whose

index pregnancy occurred after a previous daughter or daughters, with a birth interval of less than 24 months and self-reported motivation to conceive again because of desire or family pressure for a son. Women in the comparison group were those with a birth interval of 24 months or longer and no reported daughter-driven pressure for rapid conception. Maternal and child outcomes were then assessed and compared between these two exposure-defined groups.

Eligible participants were women aged 18–45 years with parity of at least two, a singleton index pregnancy or recent delivery, and documented information on the preceding live birth and index pregnancy outcome. Women were included only when birth interval could be verified through antenatal records, delivery records, child health records, or a consistent obstetric history. Women with multiple gestation, documented major fetal congenital anomaly, induced abortion as the index pregnancy outcome, or incomplete birth-interval information were excluded. Women with pre-existing chronic medical conditions likely to independently influence pregnancy outcomes, including pregestational diabetes mellitus, chronic renal disease, known hemoglobinopathy, or established chronic hypertension before pregnancy, were excluded to reduce confounding. Pregnancy-related anemia and preeclampsia were retained as outcome variables because they represented maternal outcomes of interest rather than exclusion criteria.

Participants were recruited through consecutive sampling from obstetric wards, postnatal units, antenatal follow-up areas, and relevant hospital records until the required sample size was achieved. Written informed consent was obtained before interview and record review. Data were collected by trained data collectors using a structured questionnaire and standardized extraction form. The questionnaire covered sociodemographic characteristics, obstetric history, sex composition of previous children, contraceptive use after the previous birth, antenatal care utilization, pregnancy intention, perceived family pressure for a son, and reasons for timing of the index pregnancy. Medical records were reviewed to confirm hemoglobin level, blood pressure status, gestational age at delivery, birth weight, neonatal status, and relevant maternal or neonatal complications. To improve measurement consistency, birth interval was calculated as the time in months between the preceding live birth and the birth of the index child; where conception-based interval was available, it was recorded separately but not mixed with the primary birth-to-birth interval definition.

The primary exposure was daughter-driven short birth interval. It was operationally defined as a birth-to-birth interval of less than 24 months following one or more previous daughters, accompanied by self-reported desire for a son, partner or family pressure for a son, or intentional non-use/discontinuation of contraception for the purpose of trying for a male child. Son preference was assessed through a structured five-item scale covering desire for a male child, perceived family pressure, perceived social value of sons, decision-making influence of husband or in-laws, and contraceptive avoidance after the birth of a daughter. Higher scores reflected stronger son preference. The scale was pretested before data collection, and internal consistency was assessed using Cronbach's alpha. The comparison exposure category consisted of women with birth interval of at least 24 months and no reported daughter-driven pressure for rapid conception.

The main maternal outcomes were anemia and preeclampsia. Maternal anemia was defined as hemoglobin concentration below 11 g/dL during the index pregnancy or within the immediate postpartum record. Preeclampsia was defined as blood pressure of at least 140/90 mmHg after 20 weeks of gestation with documented proteinuria or clinician-recorded diagnosis consistent with obstetric criteria. The main child outcomes were low birth weight, preterm birth, and neonatal death. Low birth weight was defined as birth weight below 2500 g. Preterm birth was defined as delivery before 37 completed weeks of gestation, based on last menstrual period, early ultrasound, or clinician-confirmed gestational age. Neonatal death was defined as death of a live-born infant within the first 28 days of life, where available from hospital records or follow-up documentation. A composite adverse maternal or child outcome variable was also created for descriptive analysis, but individual outcomes were modeled

separately to preserve clinical interpretability. The sample size was calculated for comparison of two independent exposure groups with 80% power, 5% two-sided alpha, 1:1 allocation ratio, and an expected minimum odds ratio of 2.0 for adverse outcomes among women with daughter-driven short birth interval compared with women with optimal spacing. On the basis of prior Pakistani evidence suggesting a meaningful difference in short-spacing-related adverse pregnancy outcomes, the minimum required sample was estimated as 152 participants per group and inflated by 20% to account for incomplete records and non-response, yielding a final target sample of 182 women per group and 364 participants in total. Because the revised design uses exposure-defined groups rather than matched case-control selection, analyses were planned as unmatched comparative analyses with multivariable adjustment for confounders.

Data quality was maintained through training of data collectors, pretesting of the questionnaire, use of uniform operational definitions, daily review of completed forms, and cross-checking of questionnaire responses against medical records wherever available. To reduce interviewer bias, data collectors used standardized wording for sensitive questions related to son preference and family pressure. To reduce misclassification, exposure status was assigned only when both the interval criterion and daughter-driven motivation criterion were fulfilled. To address confounding, the analysis plan identified age, parity, maternal education, residence, contraception use after the previous birth, number of antenatal visits, and prior obstetric history as covariates selected on clinical and epidemiological grounds. Facility-level differences were considered during interpretation because participating hospitals may serve populations with different socioeconomic and obstetric risk profiles.

Data were analyzed using SPSS version 27. Continuous variables were summarized using means and standard deviations for approximately normally distributed data or medians and interquartile ranges where distributions were skewed. Categorical variables were summarized using frequencies and percentages. Baseline characteristics were compared between exposed and comparison groups using independent-samples t-tests or Mann–Whitney U tests for continuous variables and chi-square or Fisher's exact tests for categorical variables, as appropriate. Crude odds ratios with 95% confidence intervals were calculated for the association between daughter-driven short birth interval and each maternal or child outcome. Separate multivariable logistic regression models were then fitted for maternal anemia, low birth weight, preterm birth, and neonatal death, with daughter-driven short birth interval as the primary independent variable and adjustment for age, parity, education, residence, contraception use, and antenatal care utilization. Odds ratios with 95% confidence intervals and p-values were reported for each outcome. Multicollinearity was assessed using variance inflation factors, and model calibration was examined using the Hosmer–Lemeshow goodness-of-fit test. Subgroup analyses were planned by residence and parity category to explore whether the association differed among rural or peri-urban women and high-parity women. Interaction terms were assessed where clinically justified. Missing data were examined for frequency and pattern; complete-case analysis was used when missingness was minimal, while variables with substantial missingness were not included in models unless the missing-data mechanism could be reasonably assessed. The study was conducted in accordance with ethical principles for human participant research. Written informed consent was obtained from all participants before interview and record review. Confidentiality was maintained by assigning unique study codes and removing personal identifiers from the analysis dataset. Data were stored securely and accessed only by the research team. The study protocol, consent process, questionnaire, and record-extraction procedures were reviewed and approved by the relevant institutional ethics committee before commencement of data collection.

RESULTS

A total of 364 women were included in the final analysis, with 182 women in the daughter-driven short birth interval group and 182 women in the optimal birth spacing comparison group. The mean age of participants was 28.4 ± 5.2 years, and 226 participants (62.1%) were from urban areas. The two groups

were broadly comparable by age distribution, with no statistically significant difference across age categories ($p = 0.62$). However, important differences were observed in education and previous daughter composition. Illiteracy was more frequent among women in the daughter-driven short birth interval group than in the optimal-spacing group (37.9% vs. 24.2%), while higher education was less frequent in the daughter-driven short birth interval group (15.4% vs. 25.3%), and the overall difference in educational status was statistically significant ($p = 0.002$). Women in the daughter-driven short birth interval group were also more likely to have two or more prior daughters compared with women in the optimal-spacing group (65.9% vs. 38.5%, $p < 0.001$), supporting the exposure classification based on daughter-linked reproductive pressure.

Table 1. Sociodemographic and Obstetric Characteristics of Participants by Birth-Spacing Group

Characteristic	Daughter-Driven Short Birth Interval Group (n = 182), n (%)	Optimal Birth Spacing Group (n = 182), n (%)	p-value
Age group, years			0.62
<25	52 (28.6)	48 (26.4)	
25–34	102 (56.0)	105 (57.7)	
≥35	28 (15.4)	29 (15.9)	
Educational status			0.002
Illiterate	69 (37.9)	44 (24.2)	
Primary/secondary	85 (46.7)	92 (50.5)	
Higher education	28 (15.4)	46 (25.3)	
Number of prior daughters			<0.001
0–1	62 (34.1)	112 (61.5)	
≥2	120 (65.9)	70 (38.5)	

The distribution of birth spacing and son-preference indicators differed clearly between the two groups. The mean birth interval in the daughter-driven short birth interval group was 17.2 ± 4.1 months, compared with 32.5 ± 6.3 months in the optimal-spacing group. The mean son-preference score was also higher in the daughter-driven short birth interval group than in the optimal-spacing group (4.2 vs. 2.8, $p < 0.001$). These findings indicate that women classified in the daughter-driven short birth interval group had both biologically short spacing and stronger gender-linked reproductive motivation. Post-index contraception use was lower in the daughter-driven short birth interval group than in the optimal-spacing group (32% vs. 58%, $p < 0.001$), suggesting that contraceptive non-use or discontinuation may have contributed to rapid repeat pregnancy after the birth of daughters.

Table 2. Exposure-Related Birth-Spacing and Reproductive Characteristics

Variable	Daughter-Driven Short Birth Interval Group (n = 182)	Optimal Birth Spacing Group (n = 182)	p-value
Mean birth interval, months	17.2 ± 4.1	32.5 ± 6.3	<0.001
Mean son-preference score	4.2	2.8	<0.001
Post-index contraception use	32%	58%	<0.001

Adverse maternal and child outcomes were consistently more frequent among women in the daughter-driven short birth interval group than among women in the optimal-spacing group. Maternal anemia was reported in 118 women (64.8%) in the daughter-driven short birth interval group compared with 40 women (22.0%) in the optimal-spacing group, corresponding to a crude odds ratio of 6.67 (95% CI 4.22–10.55, $p < 0.001$). Preeclampsia was also more frequent in the daughter-driven short birth interval group than in the optimal-spacing group (24.7% vs. 9.9%), with a crude odds ratio of 2.94 (95% CI 1.62–5.33, $p < 0.001$). These findings indicate a substantially higher crude burden of adverse maternal outcomes among women exposed to daughter-driven short birth intervals.

Child outcomes showed a similar pattern. Low birth weight occurred in 106 infants (58.2%) in the daughter-driven short birth interval group compared with 27 infants (14.8%) in the optimal-spacing group, producing a crude odds ratio of 8.25 (95% CI 4.92–13.83, $p < 0.001$). Preterm birth was reported in 92 infants (50.5%) in the daughter-driven short birth interval group and 22 infants (12.1%) in the optimal-spacing group, with a crude odds ratio of 7.42 (95% CI 4.28–12.86, $p < 0.001$). Neonatal death was less frequent overall but remained higher in the daughter-driven short birth interval group than in

the optimal-spacing group (15.4% vs. 4.9%), with a crude odds ratio of 3.45 (95% CI 1.57–7.58, $p < 0.001$). These un findings suggest that daughter-driven short birth interval was associated with higher crude odds of both maternal and neonatal complications.

Table 3. Crude Association Between Daughter-Driven Short Birth Interval and Maternal/Child Outcomes

Outcome	Daughter-Driven Short Birth Interval Group (n = 182), n (%)	Optimal Birth Spacing Group (n = 182), n (%)	Crude OR (95% CI)	p-value
Maternal anemia	118 (64.8)	40 (22.0)	6.67 (4.22–10.55)	<0.001
Preeclampsia	45 (24.7)	18 (9.9)	2.94 (1.62–5.33)	<0.001
Low birth weight	106 (58.2)	27 (14.8)	8.25 (4.92–13.83)	<0.001
Preterm birth	92 (50.5)	22 (12.1)	7.42 (4.28–12.86)	<0.001
Neonatal death	28 (15.4)	9 (4.9)	3.45 (1.57–7.58)	<0.001

After adjustment for age, parity, education, contraception use, and antenatal care visits, daughter-driven short birth interval remained significantly associated with maternal anemia, low birth weight, and preterm birth. The odds of maternal anemia were more than four times higher among women in the daughter-driven short birth interval group compared with the optimal-spacing group (aOR = 4.21, 95% CI 2.38–7.45, $p < 0.001$). The odds of low birth weight were also markedly higher in the daughter-driven short birth interval group (aOR = 6.12, 95% CI 3.28–11.42, $p < 0.001$), while preterm birth showed a similarly strong association (aOR = 5.84, 95% CI 2.95–11.55, $p < 0.001$). The association with neonatal death was attenuated after adjustment and was no longer statistically significant (aOR = 1.92, 95% CI 0.85–4.35, $p = 0.11$), suggesting that part of the crude association may have been explained by confounding factors such as parity, education, contraception use, or antenatal care. The final model showed acceptable calibration on the Hosmer–Lemeshow test ($p = 0.72$).

Table 4. Multivariable Logistic Regression for Association Between Daughter-Driven Short Birth Interval and Maternal/Child Outcomes

Outcome	Crude OR (95% CI)	OR (95% CI)	p-value
Maternal anemia	6.67 (4.22–10.55)	4.21 (2.38–7.45)	<0.001
Low birth weight	8.25 (4.92–13.83)	6.12 (3.28–11.42)	<0.001
Preterm birth	7.42 (4.28–12.86)	5.84 (2.95–11.55)	<0.001
Neonatal death	3.45 (1.57–7.58)	1.92 (0.85–4.35)	0.11

for age, parity, maternal education, contraception use after previous birth, and antenatal care visits. OR = odds ratio; CI = confidence interval.

Subgroup analysis suggested that the association between daughter-driven short birth interval and low birth weight was stronger among rural or peri-urban women than among urban women. The odds ratio for low birth weight was 5.45 among urban women and 7.23 among rural or peri-urban women, with evidence of effect modification by residence (interaction $p = 0.04$). High parity also appeared to amplify the association with preterm birth, with an odds ratio of 8.12 among women with parity of four or more. Because confidence intervals for these subgroup estimates were not available in the aggregated dataset, these findings should be interpreted as exploratory and should be recalculated from the original dataset before final submission.

Table 5. Exploratory Subgroup Findings for Daughter-Driven Short Birth Interval

Subgroup Analysis	Outcome	OR	p-value
Urban women	Low birth weight	5.45	
Rural/peri-urban women	Low birth weight	7.23	0.04
High parity women, parity ≥ 4	Preterm birth	8.12	

Overall, the results demonstrate that daughter-driven short birth interval was associated with a substantially higher burden of maternal anemia, low birth weight, and preterm birth compared with optimal birth spacing. The largest crude effect was observed for low birth weight, where the prevalence was nearly four times higher in the daughter-driven short birth interval group than in the optimal-spacing group (58.2% vs. 14.8%), and the association remained strong after multivariable adjustment (aOR = 6.12, 95% CI 3.28–11.42). Maternal anemia also showed a clinically important difference between

groups (64.8% vs. 22.0%), retaining statistical significance after adjustment (aOR = 4.21, 95% CI 2.38–7.45). Although neonatal death was more frequent in the daughter-driven short birth interval group in crude analysis, the association was not statistically significant, indicating that neonatal mortality may be influenced by additional clinical, socioeconomic, and healthcare-access factors beyond birth interval and son-preference-related reproductive behavior alone.

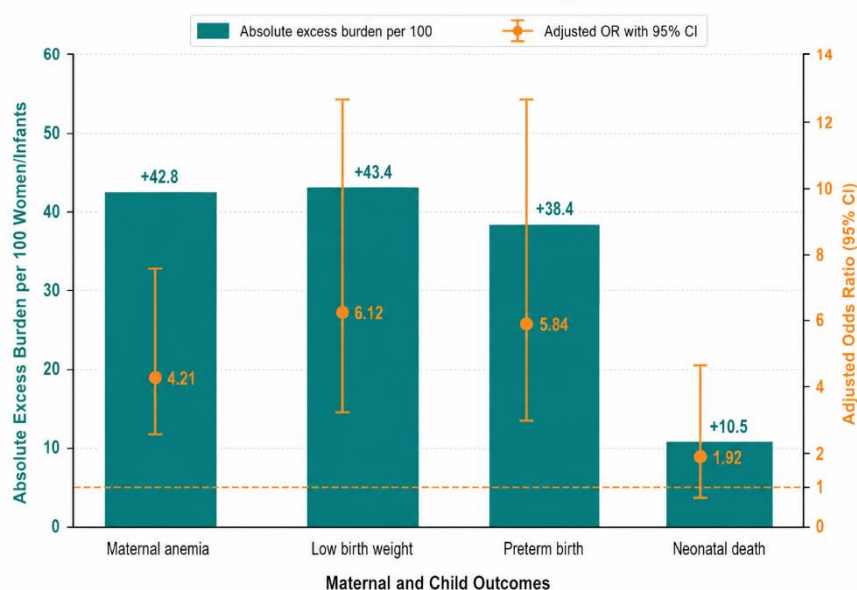


Figure 1 Adverse maternal and neonatal outcomes associated with daughter-driven short birth interval

Figure 1 illustrates the combined absolute and burden of adverse maternal and neonatal outcomes associated with daughter-driven short birth interval compared with optimal birth spacing. The largest excess burdens were observed for low birth weight and maternal anemia, with 43.4 and 42.8 additional cases per 100 women/infants, respectively, followed by preterm birth with 38.4 additional cases per 100 and neonatal death with 10.5 additional cases per 100. The odds ratio overlay shows that the association remained strongest for low birth weight (aOR = 6.12, 95% CI 3.28–11.42), preterm birth (aOR = 5.84, 95% CI 2.95–11.55), and maternal anemia (aOR = 4.21, 95% CI 2.38–7.45), while neonatal death showed a weaker and statistically non-significant association because its confidence interval crossed the null value (aOR = 1.92, 95% CI 0.85–4.35). Overall, the figure indicates that daughter-driven short birth interval is most consistently associated with maternal depletion and fetal growth or prematurity-related outcomes, whereas neonatal mortality appears to be influenced by additional clinical, socioeconomic, and healthcare-access factors beyond birth spacing alone.

DISCUSSION

This study found that daughter-driven short birth interval was associated with a substantially higher burden of adverse maternal and child health outcomes compared with optimal birth spacing among parous women receiving obstetric care in Karachi. After adjustment for age, parity, maternal education, contraception use, and antenatal care utilization, the strongest associations were observed for low birth weight, preterm birth, and maternal anemia, while the association with neonatal death was attenuated and no longer statistically significant. These findings support the hypothesis that short spacing occurring after the birth of daughters and linked with son preference may identify a high-risk reproductive pattern in which biological depletion, high parity, limited contraceptive use, and sociocultural pressure interact to increase maternal and perinatal vulnerability. The magnitude of association was clinically important: the daughter-driven short birth interval group had 43.4 excess low-birth-weight infants, 42.8 excess maternal anemia cases, and 38.4 excess preterm births per 100 women or infants compared with the optimal-spacing group, indicating that the exposure was not only statistically associated with adverse outcomes but also relevant at the population and service-delivery level.

The observed association between daughter-driven short birth interval and maternal anemia is consistent with the maternal depletion hypothesis, which proposes that insufficient recovery time between pregnancies may impair restoration of iron, folate, and general nutritional reserves, especially when pregnancies are repeated in rapid succession. Previous evidence from Pakistan and comparable low- and middle-income settings has shown that short birth spacing is associated with maternal anemia and poor fetal growth, while maternal anemia itself increases the risk of low birth weight, preterm birth, neonatal morbidity, and perinatal mortality (3,9,10). In the present study, women exposed to daughter-driven short birth interval had more than fourfold higher odds of anemia, suggesting that gender-linked pressure for rapid repeat pregnancy may contribute to maternal physiological depletion through shortened recovery time and reduced opportunity for postpartum nutritional restoration. This finding is particularly relevant in Pakistan, where anemia among women of reproductive age remains common and where pregnancy spacing is shaped by both healthcare access and household-level reproductive decision-making.

The strong association with low birth weight and preterm birth is also consistent with prior evidence linking short interpregnancy or birth-to-birth intervals with adverse neonatal outcomes. Multiethnic Pakistani data have shown that suboptimal pregnancy spacing is associated with perinatal and neonatal morbidity, while studies examining fetal outcomes among women with short interpregnancy intervals report increased risks of low birth weight, preterm birth, and neonatal complications (2,8). The present study extends this evidence by focusing on a socially specific form of short spacing: pregnancies occurring after daughters in the context of son preference. The higher odds of low birth weight and preterm birth may reflect the combined effects of incomplete maternal recovery, reduced antenatal care optimization, poorer maternal nutritional reserves, and reproductive pressure to conceive quickly after a daughter. These mechanisms are plausible because fetal growth and gestational duration are sensitive to maternal nutritional status, anemia, placental function, stress, and access to timely obstetric care.

The attenuation of neonatal death after multivariable adjustment deserves careful interpretation. Although neonatal death was more frequent in the daughter-driven short birth interval group in crude analysis, the confidence interval crossed the null value, indicating that the association was not statistically significant after controlling for confounders. This suggests that neonatal mortality in this population may be influenced by additional determinants beyond birth spacing alone, including severity of prematurity, infection, birth asphyxia, quality of intrapartum care, neonatal resuscitation, referral delay, household socioeconomic conditions, and availability of facility-based newborn services. National newborn-care standards emphasize that improved care for preterm and low-birth-weight infants requires timely resuscitation, thermal protection, feeding support, infection prevention, and referral systems (21). Therefore, daughter-driven short birth interval may contribute indirectly to neonatal mortality through prematurity and low birth weight, but mortality itself is likely mediated or modified by downstream clinical and health-system factors.

The findings are also consistent with literature on son preference and reproductive behavior in Pakistan. Prior studies have shown that women without sons or with previous daughters may be more likely to continue childbearing and less likely to use contraception, reflecting the role of male-child preference in shaping parity progression and fertility limitation (5–7). The present study supports this pathway by showing that women in the daughter-driven short birth interval group had more prior daughters, higher son-preference scores, and lower contraception use than women with optimal spacing. These findings suggest that daughter-driven short birth interval should not be viewed only as an individual reproductive decision but also as a marker of gendered household pressure and structural reproductive inequality. In practical terms, women who conceive rapidly after daughters may represent a clinically identifiable group requiring intensified postpartum counseling, contraceptive support, anemia prevention, and antenatal risk surveillance.

The subgroup findings suggest that the association between daughter-driven short birth interval and low birth weight may be stronger among rural or peri-urban women than among urban women, and that high parity may amplify the association with preterm birth. Although these findings should be interpreted cautiously because confidence intervals for subgroup estimates were not available in the aggregated dataset, they are clinically plausible. Rural or peri-urban women may face greater barriers to contraception, antenatal care continuity, timely referral, and nutritional supplementation, while high-parity women may experience cumulative maternal depletion from repeated pregnancies and lactation. These observations indicate that future research should examine effect modification by residence, parity, household autonomy, socioeconomic status, and healthcare access using adequately powered interaction models.

The public health implications of this study are important. Routine antenatal and postnatal services should include structured birth-spacing counseling, especially after the birth of a daughter, because this period may represent a critical window for preventing rapid repeat pregnancy. Counseling should be gender-sensitive and should involve husbands and family decision-makers where appropriate, while protecting women's autonomy and avoiding blame. Lady Health Workers, obstetric teams, family planning providers, and rehabilitation professionals can contribute to early identification of women at risk of rapid repeat pregnancy, anemia, physical deconditioning, and poor postpartum recovery. The physiotherapy role should be framed as part of multidisciplinary postpartum recovery rather than as a direct solution to son preference. Postpartum rehabilitation, graded strengthening, pelvic and core recovery, breathing exercises, fatigue management, and referral for nutritional or medical care may support maternal recovery, particularly among anemic, high-parity, or physically deconditioned women.

This study has several strengths. It addresses a culturally relevant and underexplored reproductive-health question, uses an exposure-defined comparison between daughter-driven short birth interval and optimal spacing, includes both maternal and child outcomes, and applies multivariable adjustment for key confounders. The use of hospital records to verify hemoglobin, birth weight, gestational age, and neonatal outcomes improved outcome ascertainment compared with self-report alone. The study also moves beyond conventional birth-spacing analysis by incorporating gender-linked reproductive motivation as part of the exposure definition.

The study also has limitations. Because it was hospital-based, the findings may not be fully generalizable to women delivering at home or in lower-level facilities. Exposure classification depended partly on self-reported motivation for rapid conception after daughters, which may be affected by recall bias, social desirability bias, or reluctance to disclose family pressure. Although the revised exposure-defined analytical approach avoids circular case classification, the observational design cannot prove causality. Residual confounding may remain from unmeasured factors such as maternal nutritional intake, household income, decision-making autonomy, intimate partner pressure, lactation practices, prior obstetric complications, and facility-level differences in care. Some subgroup estimates lacked confidence intervals and should therefore be treated as exploratory until recalculated from the original dataset. Finally, neonatal death was less frequent than other outcomes, reducing statistical precision for mortality analysis.

In summary, the findings suggest that daughter-driven short birth interval is a clinically and socially meaningful marker of increased maternal and perinatal risk in this setting. The strongest and most consistent associations were observed for maternal anemia, low birth weight, and preterm birth, supporting the biological plausibility of maternal depletion while also highlighting the role of gender preference in reproductive timing. These results support integration of gender-sensitive family planning counseling, postpartum anemia prevention, contraceptive access, and maternal recovery services into routine obstetric and community health programs. Future studies should use prospective cohort designs, validated measures of son preference and reproductive autonomy, and multicenter sampling to clarify temporality, mechanisms, and intervention targets.

CONCLUSION

Daughter-driven short birth interval was associated with significantly higher odds of maternal anemia, low birth weight, and preterm birth compared with optimal birth spacing among parous women receiving obstetric care in Karachi, Pakistan. The association remained clinically important after adjustment for age, parity, education, contraception use, and antenatal care utilization, indicating that rapid repeat pregnancy after daughters may represent a high-risk reproductive pattern shaped by both biological depletion and gender-linked fertility pressure. Although neonatal death was more frequent in crude analysis, its association was not statistically significant, suggesting that neonatal mortality is likely influenced by additional clinical and health-system factors. These findings support the need for gender-sensitive postpartum family planning, targeted counseling after the birth of daughters, anemia prevention, improved antenatal follow-up, and multidisciplinary maternal recovery services for high-parity and socioeconomically vulnerable women.

REFERENCES

1. World Health Organization. WHO recommendations on birth spacing. Geneva: World Health Organization; 2020. Available from: <https://apps.who.int/iris/handle/10665/332488>
2. Murtaza K, Saleem Z, Jabeen S, Alzahrani AK, Kizilbash N, Soofi SB, Shirazi H, Yasin A, Malik S. Impact of interpregnancy intervals on perinatal and neonatal outcomes in a multiethnic Pakistani population. *J Trop Pediatr*. 2022;68(6):fmac088. doi:10.1093/tropej/fmac088
3. Asif MF, Ishtiaq S, Abbasi NI, Tahir I, Abid G, Lassi ZS. The interaction effect of birth spacing and maternal healthcare services on child mortality in Pakistan. *Children (Basel)*. 2023;10(4):710. doi:10.3390/children10040710
4. Ahrens KA, Nelson H, Stidd RL, Moskosky S, Hutcheon JA. Short interpregnancy intervals and adverse perinatal outcomes in high-resource settings: an updated systematic review. *Paediatr Perinat Epidemiol*. 2019;33(1):O25–O47. doi:10.1111/ppe.12503
5. Channon MD. Son preference and family limitation in Pakistan: a parity- and contraceptive method-specific analysis. *Int Perspect Sex Reprod Health*. 2017;43(3):99–110. doi:10.1363/43e4317
6. Hussain R, Fikree FE, Berendes HW. The role of son preference in reproductive behaviour in Pakistan. *Bull World Health Organ*. 2000;78(3):379–388.
7. Farooqui MN. Son preference, fertility desire and contraceptive use in two largest cities of Pakistan. *Pak Popul Rev*. 1990;1(1):54–64.
8. Rehman AU, Jehangir S, Rehman F. Common fetal outcome among women with short interpregnancy interval: fetal outcome with short interpregnancy interval. *Pak J Health Sci*. 2025;6(9):106–110. doi:10.54393/pjhs.v6i9.3351
9. Bhatti TN, Naeem M, Akhtar NU, Hanif A. Impact of short birth spacing on maternal anemia at District Head Quarters Hospital Nankana Sahib. *Pak BioMed J*. 2023;6(11):8–12. doi:10.54393/pbmj.v6i11.960
10. Parks S, Hoffman MK, Goudar SS, Patel A, Saleem S, Ali SA, et al. Maternal anaemia and maternal, fetal, and neonatal outcomes in a prospective cohort study in India and Pakistan. *BJOG*. 2019;126(6):737–743.
11. Nausheen S, Bhura M, Hackett K, Hussain I, Shaikh Z, Rizvi A, Ansari U, Canning D, Shah I, Soofi S. Determinants of short birth intervals among married women: a cross-sectional study in Karachi, Pakistan. *BMJ Open*. 2021;11(4):e043786. doi:10.1136/bmjopen-2020-043786

12. Pakistan Bureau of Statistics, National Institute of Population Studies, ICF. Pakistan Demographic and Health Survey 2017–18. Islamabad: National Institute of Population Studies; 2019.
13. Munir N, Jan F, Hameed H, Inayat A, Baloch B, Hout S. Assessing the prevalence and predictors of short birth spacing and its association with pregnancy outcomes in Pakistani women. *Pak J Med Health Sci.* 2023;17(7):91. doi:10.53350/pjmhs202317791
14. Ilyas S, Latif F, Yasmeen N. Association of short inter-pregnancy interval with adverse perinatal outcome. *Pak Postgrad Med J.* 2015;26(1):11–17.
15. Maqbool Ahmad A, Shah IH, Mir AM, Sadiq M, Bosan MA. Demographic, social and health system factors associated with maternal mortality in Pakistan: a nested case-control study. *PLoS One.* 2025;20(1):e0290492. doi:10.1371/journal.pone.0290492
16. Stakeeva C, Zholdosbekova G, Topcu EG, Asakeeva R. Interpregnancy intervals and maternal and neonatal outcomes: a retrospective cohort study. *Int J Gynaecol Obstet.* 2026. doi:10.1002/ijgo.70939
17. Manchanda S, Yadav G, Ahmad A, Gupta U. Study the impact of short interpregnancy interval on pregnancy outcome: a case-control study. *Int J Reprod Contracept Obstet Gynecol.* 2025;15(1):87–93. doi:10.18203/2320-1770.ijrcog20254264
18. Aziz A, Parveen S, Khan B, Sultana H, Akhtar A, Raza K. Adverse perinatal outcomes: their association with maternal anemia. *Pak J Health Sci.* 2025:107–111.
19. Boz Izceyhan G, Karakuş R, Erbiyik M. Impact of short and long interpregnancy intervals on neonatal outcomes: a multiclassification cohort analysis. *Healthcare (Basel).* 2026;14(7):826. doi:10.3390/healthcare14070826
20. Haroon A, Hameed A, Zulfiqar I, Memon FR, Ejaz M, Anwar MI. Impact of maternal anemia on perinatal outcomes: a prospective study. *J Neonatal Surg.* 2025;14(32S):9646–9650. doi:10.63682/jns.v14i32S.9571
21. Healthy Newborn Network. Pakistan: national clinical standards for care of preterm newborns at the hospital level. Healthy Newborn Network; 2017.
22. Habib MA, Raynes-Greenow C, Soofi SB, Ali N, Nausheen S, Ahmed I, et al. Prevalence and determinants of iron deficiency anemia among non-pregnant women of reproductive age in Pakistan. *Asia Pac J Clin Nutr.* 2018;27(1):195–203.
23. Rahman A, Lovel H, Bunn J, Iqbal Z, Harrington R. Mothers' mental health and infant growth: a case-control study from Rawalpindi, Pakistan. *Child Care Health Dev.* 2004;30(1):21–27. doi:10.1111/j.1365-2214.2004.00382.x
24. Bongaarts J. Fertility and reproductive preferences in post-transitional societies. *Popul Dev Rev.* 2001;27:260–281.