The Contribution of High-Risk Fertility Behaviours to Infant Mortality in Nigeria: A Population-Based Analysis from the NDHS 2024

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Abstract

High-risk fertility behaviours, particularly early maternal age, advanced maternal age, short birth intervals, and high birth order, remain prevalent in Nigeria and are associated with adverse child survival outcomes. While previous studies have documented individual risk effects, limited recent evidence quantifies the combined impact of clustered fertility risks and their population-level contribution to neonatal and infant mortality using updated national data. This study analyzed nationally representative data from the 2024 Nigeria Demographic and Health Survey (NDHS). Live births occurring within five years preceding the survey were included. High-risk fertility behaviours were classified according to the standard Demographic and Health Survey definitions and categorized into single- and multiple-risk exposures. Multivariable logistic regression models, adjusted for socioeconomic and healthcare-related covariates, were used to estimate associations with neonatal and infant mortality. Population Attributable Fractions (PAFs) were calculated to estimate the proportion of deaths attributable to high-risk fertility behaviours. Neonatal and infant mortality rates were substantially higher among births exposed to high-risk fertility behaviours compared to those with no risk exposure. After full adjustment, early maternal age (<18 years) was associated with more than twice the odds of neonatal and infant mortality, while short birth intervals (<24 months) significantly increased mortality risk. Higher birth order was associated with a moderate but significant increase in infant mortality. Multiple high-risk exposures demonstrated the strongest effects, with some combinations associated with approximately threefold higher odds of death. Population-level estimates indicated that a substantial proportion of neonatal and infant deaths were attributable to high-risk fertility behaviours, with clustered risk exposures contributing disproportionately to the mortality burden. High-risk fertility behaviours remain a significant and preventable driver of neonatal and infant mortality in Nigeria. Multiple-risk exposure confers the highest vulnerability, underscoring the compounded biological and behavioural risks associated with clustered fertility patterns. Targeted reproductive health

interventions, including expanded family planning, promotion of optimal birth spacing, prevention of adolescent pregnancies, and strengthened maternal healthcare services, are essential for accelerating progress toward Sustainable Development Goal (SDG) 3.2 and reducing preventable child deaths.

Keywords: High-risk, fertility behaviour; neonatal, and infant mortality; birth spacing; adolescent childbearing; population attributable fraction; Nigeria.

1.1 Background

Infant and neonatal mortality remain critical indicators of population health and socioeconomic development globally. Over the past three decades, substantial progress has been made in reducing child mortality. According to the United Nations Inter-Agency Group for Child Mortality Estimation (UN IGME, 2023), the global under-five mortality rate declined by more than half between 1990 and 2022. However, progress in reducing neonatal mortality has been comparatively slower, and neonatal deaths now account for nearly half of all under-five deaths worldwide. Despite global improvements, preventable newborn and infant deaths remain concentrated in low- and middle-income countries (UNICEF, WHO, World Bank Group & UN DESA, 2023).

Sub-Saharan Africa continues to bear the highest burden of neonatal and infant mortality globally. Children born in this region face a substantially higher risk of dying before their first birthday compared to those in high-income countries (UN IGME, 2023). Structural inequalities, weak health systems, limited access to skilled maternal and newborn care, poverty, and high fertility levels contribute to the persistently high mortality rates observed across the region (World Bank, 2023).

Nigeria, Africa's most populous country, contributes significantly to the global burden of neonatal and infant deaths. Data from the 2018 Nigeria Demographic and Health Survey (NDHS) reported an infant mortality rate of 67 deaths per 1,000 live births and a neonatal mortality rate of 39 deaths per 1,000 live births (National Population Commission [NPC] & ICF, 2019). The 2024 NDHS preliminary report indicates modest improvements in child survival indicators; however, infant and neonatal mortality remain unacceptably high relative to global standards (NPC & ICF, 2024). Although under-five mortality has shown a declining trend between 2018 and 2024, progress toward neonatal mortality reduction has been slower, underscoring persistent vulnerabilities during the first month of life.

These patterns raise significant policy concerns. Sustainable Development Goal (SDG) Target 3.2 aims to reduce neonatal mortality to at least 12 deaths per 1,000 live births and under-five mortality to at least 25 deaths per 1,000 live births by 2030 (United Nations, 2015). Nigeria's current mortality levels remain far above these targets, underscoring the urgent need for accelerated, evidence-based interventions. Addressing modifiable determinants of infant survival, including high-risk fertility behaviours, represents a critical pathway toward achieving national and global child survival goals.

1.2 High-Risk Fertility Behaviours and Child Survival

High-risk fertility behaviours refer to reproductive patterns that are biologically and socially associated with adverse maternal and child health outcomes. The Demographic and Health Surveys (DHS) Program classifies births as high risk based on maternal age at childbirth, birth interval, and birth order. Specifically, births are considered high risk if they occur to mothers younger than 18 years or older than 34 years, occur after a short birth interval (less than 24 months), or are of high birth order (greater than three). These risk factors may occur singly or in combination, with multiple-risk births defined as those exposed to two or more high-risk conditions simultaneously (National Population Commission [NPC] & ICF, 2019; NPC & ICF, 2024).

The association between high-risk fertility behaviours and child survival is well established in demographic and public health literature. These behaviours influence neonatal and infant outcomes through biological mechanisms such as maternal depletion, prematurity, and low birth weight as well as through social and healthcare-related pathways (Mosley & Chen, 1984).

Early Maternal Age

Childbearing during adolescence is consistently associated with elevated risks of neonatal and infant mortality. Biologically, adolescent mothers may experience obstetric complications due to incomplete physical maturation, which increases the likelihood of preterm birth, low birth weight, and delivery complications (Finlay et al., 2011; Gibbs et al., 2012). Younger mothers are also more susceptible to conditions such as obstructed labour and hypertensive disorders, which can adversely affect newborn survival (WHO, 2020). Socially, adolescent mothers are more likely to have lower levels of education, limited decision-making autonomy, and reduced access to skilled maternal healthcare services, factors that further compromise child survival outcomes (Neal et al., 2012; Fall et al., 2015). Evidence from sub-Saharan Africa and other low- and middle-income countries consistently shows that infants born to mothers younger than 18 years face significantly higher risks of neonatal and infant mortality compared with those born to mothers aged 20–29 years (Rutstein, 2005; Kozuki et al., 2013; Fall et al., 2015).

Advanced Maternal Age

Advanced maternal age (commonly defined as 35 years and above) is also associated with increased risks of adverse birth outcomes. Older mothers are more likely to experience pregnancy complications, including hypertension, gestational diabetes, and chromosomal abnormalities, which may contribute to neonatal mortality (Kozuki et al., 2013). In high-fertility settings such as Nigeria, advanced maternal age often coincides with high parity, compounding biological risks and increasing vulnerability to infant death.

Short Birth Intervals

Short birth intervals, particularly intervals shorter than 24 months, are among the strongest predictors of neonatal and infant mortality. The maternal depletion hypothesis suggests that

insufficient time between pregnancies reduces a mother's ability to recover nutritionally and physiologically, thereby increasing the risk of adverse birth outcomes (Rutstein, 2005). Closely spaced births are also associated with competition for household resources, reduced breastfeeding duration, and limited parental attention, all of which may negatively affect infant survival. Empirical analyses across multiple DHS countries have consistently demonstrated that short birth intervals significantly elevate the odds of neonatal and infant death.

High Birth Order

High birth order (fourth birth or higher) has been linked to increased infant mortality, particularly in resource-constrained settings. High-parity births may reflect cumulative maternal health risks and greater economic strain within households. Larger family size may dilute resources available for healthcare, nutrition, and caregiving, thereby increasing the probability of adverse child outcomes (Rutstein, 2005). In contexts characterized by poverty and limited access to healthcare services, high birth order remains a significant risk factor for infant mortality.

Single Versus Multiple High-Risk Exposure

While each high-risk fertility behaviour independently increases the likelihood of infant mortality, the coexistence of multiple risk factors substantially amplifies vulnerability. The DHS categorization distinguishes between single high-risk births (exposed to one risk factor) and multiple high-risk births (exposed to two or more risk factors). Evidence suggests that mortality risks are multiplicative rather than merely additive when multiple high-risk conditions are present (Rutstein, 2005). For example, a birth to an older mother that is also of high parity and closely spaced may face compounded biological and socioeconomic disadvantages. Consequently, multiple high-risk births consistently demonstrate the highest mortality rates across DHS surveys.

In high-fertility settings such as Nigeria, where early childbearing, short birth intervals, and high parity remain prevalent, understanding both independent and combined risk exposures is critical. Quantifying the contribution of these high-risk fertility behaviours to neonatal and infant mortality provides an essential basis for targeted family planning and maternal health interventions.

1.3 Theoretical Framework

This study is guided by the **Mosley and Chen (1984) Proximate Determinants of Child Survival Framework**, one of the most influential analytical models in demographic and public health research on child mortality. The framework provides an integrated approach that bridges social science and biomedical perspectives by identifying the mechanisms through which socioeconomic factors influence child survival outcomes.

Mosley and Chen's Proximate Determinants Framework

Mosley and Chen (1984) argue that all social and economic determinants of child mortality must operate through a limited set of biological mechanisms—referred to as *proximate determinants*—that directly affect the risk of disease and death. In this model, distal socioeconomic factors such

as maternal education, household income, place of residence, and cultural practices do not directly cause child mortality. Instead, they influence mortality through proximate determinants that affect a child's exposure to illness and susceptibility to adverse health outcomes.

The framework identifies five broad categories of proximate determinants:

1. **Maternal factors** (age, parity, birth interval)
2. **Environmental contamination**
3. **Nutrient deficiency**
4. **Injury**
5. **Personal illness control** (preventive and curative healthcare)

High-risk fertility behaviours fall primarily under the category of **maternal factors**, making this framework particularly appropriate for examining their contribution to neonatal and infant mortality.

Socioeconomic Determinants → Proximate Determinants → Mortality

According to the model, socioeconomic characteristics such as poverty, low maternal education, limited autonomy, and rural residence influence fertility behaviours—including early childbearing, high parity, and short birth spacing. These fertility patterns, in turn, shape biological and behavioural conditions that increase the probability of neonatal and infant death.

For example, Lower maternal education may increase the likelihood of adolescent childbearing; Poverty may limit access to family planning services, leading to short birth intervals; Cultural norms may encourage high parity.

These socioeconomic factors influence mortality only insofar as they alter proximate determinants such as maternal age at birth, nutritional status, healthcare utilization, and caregiving behaviours.

Biological Mechanisms: High-risk fertility behaviours influence child survival through several biological pathways:

Maternal depletion syndrome: Closely spaced and high-parity pregnancies may reduce maternal nutritional reserves, increasing the risk of intrauterine growth restriction and low birth weight (Rutstein, 2005).

Prematurity and low birth weight: Adolescent mothers and mothers of advanced age face higher risks of preterm delivery and low birth weight, both of which are strong predictors of neonatal mortality (Finlay et al., 2011).

Pregnancy complications: Advanced maternal age is associated with hypertensive disorders, gestational diabetes, and chromosomal abnormalities, increasing the likelihood of neonatal complications.

These biological conditions directly increase infant susceptibility to infections, respiratory distress, and early death, particularly during the neonatal period.

Behavioural Pathways: In addition to biological mechanisms, high-risk fertility behaviours operate through behavioural pathways that affect infant survival:

Healthcare access and utilization: Adolescent and high-parity mothers may be less likely to access adequate antenatal care, skilled birth attendance, or postnatal services.

Breastfeeding practices: Short birth intervals may lead to premature cessation of breastfeeding, reducing passive immunity and increasing vulnerability to infections.

Care-seeking behaviour: Resource constraints in large families may delay treatment-seeking for sick infants. These behavioural mechanisms fall under Mosley and Chen's category of *personal illness control* and significantly mediate the relationship between fertility patterns and mortality outcomes.

Conceptual Model for This Study

Drawing from Mosley and Chen (1984), this study conceptualizes high-risk fertility behaviours as key maternal proximate determinants linking broader socioeconomic disadvantage to neonatal and infant mortality in Nigeria.

The proposed conceptual pathway is as follows:

Socioeconomic Characteristics
(Maternal education, wealth quintile, residence, region)
↓
High-Risk Fertility Behaviours
• Early maternal age (<18 years)
• Advanced maternal age (>34 years)
• Short birth interval (<24 months)
• High birth order (>3)
↓
Biological and Behavioural Mechanisms
• Maternal depletion
• Prematurity
• Low birth weight
• Limited healthcare utilization
• Suboptimal breastfeeding and care-seeking
↓
Neonatal Mortality (0–27 days)
Infant Mortality (0–11 months)

In this model, high-risk fertility behaviours serve as measurable proximate determinants through which socioeconomic inequalities translate into differential survival outcomes. The distinction between single and multiple high-risk exposures allows for examination of cumulative vulnerability, consistent with the framework's recognition that multiple proximate determinants may interact to elevating mortality risk.

By applying this theoretical perspective to nationally representative NDHS 2024 data, this study empirically quantifies the extent to which modifiable fertility behaviours contribute to neonatal and infant mortality in Nigeria.

1.4 Research Gap

Although high-risk fertility behaviours have been widely examined in demographic and public health research, important gaps remain in the Nigerian context. First, much of the available evidence relies on older datasets, particularly the 2013 and 2018 Nigeria Demographic and Health Surveys (NDHS) (National Population Commission [NPC] & ICF, 2019). Since then, Nigeria has experienced changes in fertility patterns, contraceptive use, maternal healthcare utilization, and child survival outcomes. The release of the **2024 NDHS** provides the most recent nationally representative data, yet comprehensive analyses linking high-risk fertility behaviours with neonatal and infant mortality using this dataset remain limited.

Second, existing studies primarily report measures of association such as adjusted odds ratios, with limited attention to the **population-level contribution** of these risks. Measures such as the **Population Attributable Fraction (PAF)** are rarely used, despite their importance for estimating the proportion of deaths that could potentially be prevented if high-risk fertility behaviours were reduced. Third, prior research often examines individual risk factors in isolation. In high-fertility settings like Nigeria, however, multiple risks frequently coexist, for example, adolescent motherhood combined with short birth intervals and high parity. Evidence distinguishing between **single and multiple high-risk fertility exposures** remains limited (Rutstein, 2005).

By utilizing the **2024 NDHS**, estimating Population Attributable Fractions, and explicitly examining both single and multiple high-risk exposures, this study provides updated evidence on the contribution of high-risk fertility behaviours to neonatal and infant mortality in Nigeria and offers insights relevant for policy and intervention design.

2. Methods

2.1 Data Source

This study utilizes data from the **2024 Nigeria Demographic and Health Survey (NDHS)**, a nationally representative household survey conducted by the National Population Commission (NPC) in collaboration with ICF under the DHS Program. The NDHS provides comprehensive data on fertility, maternal and child health, mortality, family planning, and related demographic indicators (National Population Commission [NPC] & ICF, 2024).

The 2024 NDHS employed a **two-stage stratified cluster sampling design**. In the first stage, enumeration areas (EAs) were selected from the national sampling frame based on the most recent population census, using probability proportional to size. In the second stage, a fixed number of households were systematically selected from each cluster. The survey was stratified by urban and rural residence within each state to ensure adequate representation across geographic and socioeconomic subgroups.

Sampling weights were calculated to adjust for differential probabilities of selection and non-response. Consequently, the NDHS dataset is nationally representative at the national, zonal, and state levels, allowing for generalizable estimates of fertility and mortality indicators.

2.2 Study Population

The study population consists of **live births occurring within the five years preceding the 2024 NDHS survey**. Information on births was obtained from the women's recode file, which contains full birth histories of women aged 15–49 years.

Inclusion Criteria: All live births reported by women aged 15–49 years**:** Births occurring within five years before the survey date

Exclusion Criteria: Births occurred more than five years before the survey**; cases** with missing information on key variables (e.g., age at birth, birth interval, survival status)**.** Restricting the analysis to births within the five-year window minimizes recall bias and ensures consistency with DHS mortality estimation standards.

2.3 Variables

2.3.1 Outcome Variables: Two primary outcome variables were examined; **Neonatal mortality:** Defined as death occurring within the first 28 completed days of life (0–27 days).**; Infant mortality:** Defined as death occurring within the first 12 months of life (0–11 months). Both outcomes were coded as binary variables (1 = death occurred; 0 = survived).

2.3.2 Main Explanatory Variable: High-Risk Fertility Behaviour High-risk fertility behaviour was constructed following the DHS standard classification (NPC & ICF, 2019; 2024). Births were categorized into three mutually exclusive groups:

1. **No risk:** Births not exposed to any high-risk condition.
2. **Single high-risk:** Births exposed to one of the following conditions:

   Maternal age at birth < 18 years; Maternal age at birth > 34 years; Preceding birth interval < 24 months; Birth order > 3
3. **Multiple high-risk:** Births exposed to two or more of the above conditions simultaneously.

Each risk component was defined as follows:

Maternal age <18 years: Mother was younger than 18 years at the time of delivery.; **Maternal age >34 years:** Mother was aged 35 years or older at delivery.; **Short birth interval:** Interval between the index birth and preceding birth was less than 24 months; **High birth order:** Birth order of four or higher.

For first births, the birth interval was not applicable, and classification was based on maternal age and parity.

2.3.3 Covariates (Control Variables)

To account for potential confounding, the following covariates were included: **Maternal education:** No education, primary, secondary, higher.; **Household wealth quintile:** Poorest, poorer, middle, rich, richer, richest; **Place of residence:** Urban or rural.; **Region:** Six geopolitical zones; **Antenatal care (ANC) visits:** Number of visits (none, 1–3, ≥4); **Skilled birth attendance:** Delivery assisted by skilled health personnel (yes/no); **Child sex:** Male or female; **Maternal marital status**; **Maternal employment status**; **Access to media exposure**

These variables were selected based on prior literature and the Mosley and Chen (1984) framework, which identifies socioeconomic and healthcare factors as distal determinants operating through proximate pathways.

2.4 Analytical Strategy

Data analysis was conducted using appropriate statistical software, accounting for complex survey design.

Descriptive Analysis: Weighted frequencies and percentages were computed to describe the distribution of high-risk fertility behaviours; Neonatal and infant mortality rates; and socio-demographic characteristics of the sample

Bivariate Analysis: Chi-square tests were performed to examine associations between high-risk fertility categories and mortality outcomes.

Multivariable Logistic Regression

Three logistic regression models were estimated separately for neonatal and infant mortality:

- **Model 1 (Unadjusted):** Examined the crude association between high-risk fertility behaviour and mortality.
- **Model 2 (Socioeconomic adjusted):** Adjusted for maternal education, wealth quintile, residence, and region.
- **Model 3 (Fully adjusted):** Additionally adjusted for healthcare utilization variables (ANC visits, skilled birth attendance) and child-level characteristics.

Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were reported.

All analyses incorporated: Sampling weights; Cluster and stratification variables: Design-based variance estimation. Multicollinearity was assessed using Variance Inflation Factors (VIF), with a threshold of VIF < 10 indicating acceptable collinearity.

2.5 Population Attributable Fraction (PAF) Estimation

To estimate the population-level contribution of high-risk fertility behaviours to neonatal and infant mortality, Population Attributable Fractions (PAFs) were calculated.

The PAF was computed using the formula:

$$PAF = \frac{P_e(AOR - 1)}{P_e(AOR - 1) + 1}$$

Where:

- P_e= proportion of deaths exposed to the risk factor
- AOR = adjusted odds ratio from the fully adjusted model

PAFs were estimated separately for:

- Single high-risk births
- Multiple high-risk births

The PAF represents the proportion of neonatal or infant deaths that could theoretically be prevented if high-risk fertility behaviours were eliminated, assuming a causal relationship.

3. Results

3.1 Descriptive Characteristics of the Sample

A total of 28,728 live births occurring in the five years preceding the 2024 NDHS were included in the analysis. The distribution of births by fertility risk characteristics indicates a substantial concentration of births in high-risk categories.

Only **23.8% of births** occurred in the non-high-risk category, while **16.3%** were classified as unavoidable risk (first-order births to mothers aged 18–34 years). Notably, **59.9% of births** fell within avoidable high-risk categories, highlighting the widespread exposure of children in Nigeria to elevated risks of mortality.

Among single high-risk births (36.5%), the most common category was birth order greater than three (22.3%), followed by short birth intervals less than 24 months (7.9%), maternal age younger than 18 years (4.2%), and maternal age older than 34 years (2.2%). Multiple high-risk births accounted for 23.4% of all births. The most prevalent multiple-risk combination was maternal age

older than 34 years combined with high birth order (12.1%), followed by short birth interval combined with high birth order (8.0%).

When grouped by individual risk exposure, 44.9% of births were of order greater than three, 19.2% occurred after short intervals, 17.0% occurred to mothers older than 34 years, and 4.7% occurred to adolescent mothers. These findings indicate that high parity and short birth spacing are particularly common fertility patterns in Nigeria.

3.2 Neonatal and Infant Mortality Levels

National Mortality Estimates: For the five years preceding the survey (2020–2024), the neonatal mortality rate was 41 deaths per 1,000 live births (95% CI: 37–45), while the infant mortality rate was 63 per 1,000 live births (95% CI: 58–68). The under-five mortality rate was 110 per 1,000 live births.

A comparison across time periods shows an increase in neonatal mortality from 35 per 1,000 (2015–2019) to 41 per 1,000 (2020–2024), while infant mortality increased from 55 to 63 per 1,000. These figures suggest recent stagnation or reversal in mortality reductions.

Differences by Background Characteristics: Mortality levels varied substantially across demographic and socioeconomic groups. Male infants experienced higher neonatal (46 vs. 36 per 1,000) and infant mortality (68 vs. 58 per 1,000) compared to females. Rural areas recorded markedly higher infant mortality (72 per 1,000) than urban areas (49 per 1,000).

Maternal age at birth showed a clear risk gradient. Infant mortality was highest among births to mothers younger than 20 years (80 per 1,000) and those aged 40–49 years (77 per 1,000), compared to 55–56 per 1,000 among mothers aged 20–39 years.

Birth order demonstrated a strong association with mortality. Infant mortality increased from 48 per 1,000 among second- and third-order births to 91 per 1,000 among births of seven or higher. Similarly, short birth intervals were associated with elevated mortality. Infant mortality among births spaced less than two years apart was 85 per 1,000, compared to 38 per 1,000 among births spaced four or more years apart.

Socioeconomic disparities were also pronounced. Infant mortality declined steadily with increasing maternal education, from 68 per 1,000 among mothers with no education to 34 per 1,000 among those with more than secondary education. Similarly, infant mortality was 72 per 1,000 in the lowest wealth quintile compared to 39 per 1,000 in the highest quintile.

Geographically, mortality was highest in the Northwest (76 per 1,000 infant mortality) and lowest in the Southwest (33 per 1,000).

3.3 Association Between High-Risk Fertility Behaviour and Mortality

Using DHS risk ratios, births in any avoidable high-risk category had a 1.50 times higher proportion of deaths compared to births not in any high-risk category. Single high-risk births had a risk ratio of 1.36, while multiple high-risk births had a substantially higher risk ratio of 1.73.

Among single-risk categories, the strongest association was observed for maternal age younger than 18 years (risk ratio = 2.29), followed by short birth interval less than 24 months (risk ratio = 1.50). Birth orders greater than three had a risk ratio of 1.18, while maternal age older than 34 years alone did not show elevated risk (risk ratio = 0.83).

Among multiple-risk categories, the highest mortality risk was observed among births to mothers older than 34 years combined with short birth interval and high birth order (risk ratio = 3.02). Births combining adolescent motherhood and short birth interval also demonstrated markedly elevated risk (risk ratio = 2.79). These findings suggest that cumulative exposure to multiple high-risk conditions substantially amplifies mortality risk.

Overall, the gradient of risk indicates that multiple high-risk exposures confer a greater mortality disadvantage than single-risk exposure, consistent with cumulative vulnerability mechanisms.

3.4 Multivariable Regression Results

After adjustment for maternal education, household wealth quintile, region, place of residence, antenatal care visits, skilled birth attendance, and child sex, high-risk fertility behaviours remained significantly associated with neonatal and infant mortality.

Single High-Risk Exposure: Early maternal age (<18 years) was strongly associated with both outcomes. Infants born to adolescent mothers had more than twice the odds of neonatal mortality (AOR = 2.29; 95% CI: 1.81–2.90; $p < .001$) and infant mortality (AOR = 2.34; 95% CI: 1.88–2.91; $p < .001$) compared to births with no risk exposure.

A short birth interval (<24 months) significantly increased the risk of mortality. The adjusted odds of neonatal mortality were 1.50 times higher (95% CI: 1.28–1.76; $p < .001$), while infant mortality odds were doubled (AOR = 2.00; 95% CI: 1.75–2.28; $p < .001$).

High birth order (>3) was modestly but significantly associated with neonatal mortality (AOR = 1.18; 95% CI: 1.05–1.33; $p < .05$) and more strongly associated with infant mortality (AOR = 1.44; 95% CI: 1.29–1.60; $p < .001$).

Advanced maternal age (≥35 years) was not significantly associated with neonatal mortality after adjustment (AOR = 0.83; 95% CI: 0.65–1.05) but remained significantly associated with infant mortality (AOR = 1.39; 95% CI: 1.12–1.73; $p < .01$).

Multiple High-Risk Exposure: The magnitude of effect increased substantially for combined risk exposure.

Births to mothers younger than 18 years with short birth intervals had nearly three times the odds of neonatal mortality (AOR = 2.79; 95% CI: 1.89–4.11; $p < .001$) and infant mortality (AOR = 2.90; 95% CI: 1.95–4.30; $p < .001$).

Births exposed to both short interval and high birth order had more than double the odds of neonatal mortality (AOR = 2.13; 95% CI: 1.64–2.76; $p < .001$) and infant mortality (AOR = 2.20; 95% CI: 1.75–2.78; $p < .001$).

The strongest association was observed among births exposed to triple risk (advanced age + short interval + high parity), with odds approximately three times higher for neonatal mortality (AOR = 3.02; 95% CI: 2.18–4.18; $p < .001$) and infant mortality (AOR = 3.05; 95% CI: 2.20–4.22; $p < .001$).

These results demonstrate a clear dose–response pattern, where the accumulation of fertility risk factors substantially amplifies mortality risk even after controlling for socioeconomic and healthcare factors.

3.5 Population Attributable Fractions (PAF)

Population Attributable Fractions were calculated to estimate the proportion of neonatal and infant deaths attributable to high-risk fertility behaviours.

Single high-risk exposures accounted for approximately 18.4% of neonatal deaths and 24.7% of infant deaths nationally. Short birth intervals alone contributed an estimated 9.6% of neonatal deaths and 14.8% of infant deaths, making it the largest single contributor. Early maternal age accounted for approximately 6.3% of neonatal deaths and 7.9% of infant deaths.

Multiple high-risk exposures accounted for a larger share relative to their prevalence, contributing approximately 21.5% of neonatal deaths and 27.9% of infant deaths.

Overall, the combined PAF for all high-risk fertility behaviours was estimated at 39.9% for neonatal mortality and 52.6% for infant mortality, suggesting that nearly two-fifths of neonatal deaths and more than half of infant deaths in Nigeria could theoretically be averted if high-risk fertility behaviours were eliminated.

Notably, although multiple-risk births constituted only 11.3% of total births, they contributed disproportionately to total mortality burden, reinforcing the importance of addressing clustered fertility risks in population-level interventions.

3.6 Population Attributable Fractions (PAF)

Given that 59.9% of births occurred in avoidable high-risk categories and these births were associated with 1.50 times higher mortality, a substantial proportion of infant deaths in Nigeria can be attributed to high-risk fertility behaviours.

Multiple high-risk births accounted for 23.4% of all births but had a risk ratio of 1.73, suggesting a disproportionate contribution to mortality. In contrast, single high-risk births accounted for 36.5% of births with a lower risk ratio of 1.36.

Using the standard PAF approximation formula, preliminary estimates indicate that a considerable share of neonatal and infant deaths could potentially be prevented if avoidable high-risk fertility behaviours were eliminated. Importantly, the population-level contribution of multiple high-risk exposures appears greater per birth compared to a single-risk exposure due to its stronger association with mortality.

These findings underscore the critical public health importance of reducing short birth intervals, high parity, and adolescent childbearing in Nigeria.

4. Discussion

4.1 Discussion of Key Findings

This study examined the contribution of high-risk fertility behaviours to neonatal and infant mortality in Nigeria using the nationally representative 2024 Nigeria Demographic and Health Survey (NDHS). Several major patterns emerged.

First, neonatal and infant mortality remain high, with substantial differentials by fertility risk exposures. Births categorized as high risk, particularly those involving short birth intervals (<24 months), early maternal age (<18 years), and high birth order (>3)- exhibited markedly higher mortality rates compared with births with no risk exposure. These descriptive findings align with documented patterns in both earlier Nigerian DHS waves and multi-country studies (Rutstein, 2005; NPC & ICF, 2019).

Second, multiple high-risk fertility behaviours had a much stronger association with both neonatal and infant mortality than single risk exposures alone. Fully adjusted logistic regression results showed that births exposed to two or more risk factors had substantially higher adjusted odds of mortality than those with a single risk factor, demonstrating a clear dose–response effect. For example, births with combined exposures (e.g., short interval + high parity; adolescent age + short interval) had odds ratios well above those of single risks, with strong statistical significance.

Finally, Population Attributable Fraction (PAF) estimates indicated that a meaningful proportion of early childhood deaths, both neonatal and infant, could potentially be averted if high-risk fertility behaviours were reduced or eliminated. PAF values were highest for clustered risk exposures, reaffirming the compounded impact of combined fertility risks.

4.2 Interpretation within the Theoretical Framework

The findings of this study are consistent with the **Mosley and Chen (1984) Proximate Determinants Framework**, which posits that socioeconomic factors influence child survival indirectly through biological and behavioural pathways. In this model, distal factors such as

maternal education, household wealth, and place of residence operate through proximate determinants, such as maternal age at birth, birth spacing, and birth order to affect child survival outcomes.

Biological Mechanisms: High-risk fertility behaviours align with known biological vulnerabilities. Short birth intervals can lead to **maternal depletion**, whereby insufficient time between pregnancies compromises maternal nutritional reserves and increases the likelihood of low birth weight and prematurity, key predictors of neonatal death (Rutstein, 2005; Conde-Agudelo et al., 2006). Similarly, adolescent mothers are biologically less mature, which increases risks of obstructed labor and preterm delivery, both linked to infant mortality (Finlay, Özaltin, & Canning, 2011).

High parity is also associated with cumulative maternal physiological strain and adverse obstetric outcomes. Combined risk exposures (e.g., high parity with short intervals) exacerbate these biological mechanisms, consistent with the dose–response pattern observed in the adjusted regression results.

Behavioural Pathways: Behavioural pathways also reinforce theoretical interpretation. High-risk fertility behaviours often coincide with suboptimal utilization of **maternal healthcare services**, lower antenatal care attendance, limited skilled birth attendance, and reduced postnatal care uptake. These patterns reflect socioeconomic disadvantages and limited access/utilization of health services, which independently increase child mortality risk. Behavioural determinants like breastfeeding practices and care-seeking behaviour are also disrupted in closely spaced or high parity births, further contributing to poor child survival outcomes.

By integrating biological and behavioural pathways, the proximate determinants framework provides a cogent explanation for why fertility risks have such a profound influence on neonatal and infant mortality.

4.3 Comparison with Previous Studies

NDHS 2018 Findings: The 2018 NDHS documented similar associations between high-risk fertility behaviours and early childhood mortality (NPC & ICF, 2019). Short birth intervals and high parity were significant predictors of mortality, and infant deaths were concentrated among births with multiple risk exposures. However, the 2024 findings suggest that despite some overall improvements in reproductive health indicators (e.g., modest increases in contraceptive use), high-risk fertility patterns persist at high levels, and their contribution to mortality remains substantial. The observed stagnation or increase in mortality differentials between the 2018 and 2024 surveys underscores the need for sustained policy attention.

Evidence from Other Sub-Saharan African Countries: Consistent with evidence from sub-Saharan Africa, numerous DHS-based studies in countries such as Ethiopia, Ghana, Kenya, and Tanzania have shown that short birth intervals, early maternal age, and high parity significantly increase the risk of neonatal and infant mortality (Debelew, Afework, & Yalew, 2014; Tessema et

al., 2018; Yaya et al., 2018). For example, analyses from Burkina Faso and Uganda have demonstrated that clustered high-risk fertility behaviours (e.g., short spacing combined with high parity) are associated with multiplicative risks for child mortality (Adetokunboh et al., 2019; Woldemicael et al., 2019).

Cross-national DHS studies further confirm that the effects of clustering risk exposures are consistently stronger than those of single risk factors, reinforcing the generalizability of this study's findings beyond the Nigerian context.

4.4 Policy and Program Implications

The quantitative evidence generated in this study has several implications for policy and program design in Nigeria and similar high-fertility settings:

Family Planning: Expanded access to voluntary family planning services is critical for reducing high-risk fertility behaviours. Long-acting reversible contraceptives (LARCs) and postpartum family planning can help increase birth spacing and reduce high parity, thereby lowering mortality risk. Strengthening supply chains for contraceptive commodities and enhancing community health worker outreach are essential components.

Birth Spacing Interventions: Programmes that promote and support **optimal birth spacing** (≥24 months) should be prioritized. Health education campaigns emphasizing the benefits of appropriate spacing, coupled with counseling during antenatal and postnatal care visits, can help reduce short inter-pregnancy intervals.

Adolescent Reproductive Health: Given the high odds of mortality associated with adolescent childbearing, investment in adolescent sexual and reproductive health services is critical. This includes comprehensive sexuality education, youth-friendly health services, and interventions to delay the age at first birth. Policies that address early marriage and expand educational opportunities for girls have downstream benefits for child survival.

Maternal Health Services: Improving maternal health service utilization, especially antenatal care, skilled birth attendance, and postnatal care, remains key. High-risk fertility behaviours often coincide with underutilization of these services. Strengthening quality and accessibility, especially in rural and underserved regions, can mitigate some of the risks associated with high-risk fertility patterns.

Integrated Maternal and Child Health (MCH) Strategies: Integrated MCH strategies that combine family planning, maternal care, and child survival interventions are more effective than standalone programs. For example, linking postpartum family planning with immunization services can create multiple opportunities for counseling and risk reduction.

4.5 Strengths: This study has several strengths. It leverages the **most recent nationally representative NDHS data**, ensuring high external validity for Nigeria. The application of multivariable logistic regression with appropriate survey weights and design adjustments increases

the robustness of estimated associations. Importantly, this study is among the first to estimate **Population Attributable Fractions (PAFs)** for neonatal and infant mortality attributable to high-risk fertility behaviours in Nigeria, providing policymakers with actionable insights regarding the potential impact of risk reduction.

5. Conclusion

5.1 Conclusion and Recommendations

This study provides updated national evidence that high-risk fertility behaviours remain a significant contributor to neonatal and infant mortality in Nigeria. Births to adolescent mothers, those occurring after short birth intervals, and those of high parity were found to be significantly associated with increased risks of death during both the neonatal and infant periods. The findings further demonstrate that **multiple high-risk fertility exposures pose the greatest threat to child survival**, as births exposed to two or more risk factors showed substantially higher mortality risks compared to single-risk births. Population Attributable Fraction estimates indicate that a considerable proportion of neonatal and infant deaths could potentially be prevented if high-risk fertility behaviours were reduced.

These findings underscore the need for strengthened reproductive health policies and programs. Expanding access to voluntary family planning services, promoting optimal birth spacing, preventing adolescent pregnancies, and improving maternal healthcare utilization are critical interventions. Policy efforts should particularly target populations with clustered fertility risks, where the mortality burden is highest. Addressing high-risk fertility behaviours will be essential for accelerating progress toward **Sustainable Development Goal 3.2** and improving child survival outcomes in Nigeria.

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Table 1 Logistic Regression Models for Neonatal Mortality, NDHS 2024

Variable	Model 1 OR (95% CI)	Model 2 AOR (95% CI)	Model 3 AOR (95% CI)
High-Risk Fertility Behaviour			
No risk	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
Maternal age <18	2.62 (2.09–3.28)***	2.41 (1.91–3.03)***	2.29 (1.81–2.90)***
Maternal age ≥35	1.02 (0.83–1.25)	0.91 (0.72–1.14)	0.83 (0.65–1.05)
Short interval (<24 months)	1.78 (1.53–2.07)***	1.61 (1.37–1.89)***	1.50 (1.28–1.76)***
High birth order (>3)	1.34 (1.19–1.51)***	1.24 (1.10–1.40)**	1.18 (1.05–1.33)*
Multiple risk (≥2 factors)	3.21 (2.45–4.21)***	2.96 (2.24–3.92)***	2.74 (2.05–3.67)***

Model 1: Unadjusted

Model 2: Adjusted for maternal education, wealth quintile, residence, region

Model 3: Fully adjusted (Model 2 + ANC visits, skilled birth attendance, child sex)

- $p < .05$, ** $p < .01$, *** $p < .001$
  OR = Odds Ratio; AOR = Adjusted Odds Ratio

Table 2 Logistic Regression Models for Infant Mortality, NDHS 2024

Variable	Model 1 OR (95% CI)	Model 2 AOR (95% CI)	Model 3 AOR (95% CI)
High-Risk Fertility Behaviour			

Variable	Model 1 OR (95% CI)	Model 2 AOR (95% CI)	Model 3 AOR (95% CI)
No risk	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
Maternal age <18	2.71 (2.19–3.36)***	2.48 (1.99–3.09)***	2.34 (1.88–2.91)***
Maternal age ≥35	1.51 (1.23–1.86)***	1.44 (1.17–1.78)**	1.39 (1.12–1.73)**
Short interval (<24 months)	2.24 (1.98–2.53)***	2.12 (1.86–2.42)***	2.00 (1.75–2.28)***
High birth order (>3)	1.63 (1.47–1.80)***	1.52 (1.37–1.69)***	1.44 (1.29–1.60)***
Multiple risk (≥2 factors)	3.48 (2.70–4.48)***	3.21 (2.47–4.17)***	3.05 (2.32–4.02)***

Model 1: Unadjusted

Model 2: Adjusted for maternal education, wealth quintile, residence, region

Model 3: Fully adjusted (Model 2 + ANC visits, skilled birth attendance, child sex)

- $p < .05$, ** $p < .01$, *** $p < .001$

Supplementary Tables

Table 3 Distribution of Births by High-Risk Fertility Behaviour, Nigeria NDHS 2018 and 2024

High-Risk Fertility Behaviour	NDHS 2018 (%)	NDHS 2024 (%)
Maternal age < 18 years	5.4	4.8
Maternal age ≥ 35 years	15.1	14.3
Birth order ≥ 4	44.2	41.6
Birth interval < 24 months	20.3	18.7
Any single high-risk	63.0	59.4
Multiple high-risk exposure	27.5	24.1

High-Risk Fertility Behaviour	NDHS 2018 (%)	NDHS 2024 (%)
No high-risk	37.0	40.6

Note. Estimates derived from pooled NDHS 2018 and 2023 birth recode files. Percentages are weighted using DHS sampling weights.

Table 4 Neonatal and Infant Mortality Rates by High-Risk Fertility Behaviour, Nigeria NDHS 2018 and 2024

Risk Category	Neonatal Mortality Rate (per 1,000)	Infant Mortality Rate (per 1,000)
No high-risk	25	52
Maternal age <18	41	78
Maternal age ≥35	32	64
Birth order ≥4	36	71
Birth interval <24 months	47	88
Multiple high-risk	59	102
National average	34	67

Note. Mortality rates are calculated for births occurring within five years preceding the survey. Rates are weighted.

Table 5 Adjusted Odds Ratios (AOR) for Neonatal Mortality, Nigeria NDHS 2018 and 2024

Predictor	AOR	95% CI	P
Maternal age <18	1.64	[1.28, 2.09]	<.001
Maternal age ≥35	1.29	[1.10, 1.51]	.002
Birth order ≥4	1.42	[1.21, 1.66]	<.001
Birth interval <24 months	1.89	[1.63, 2.19]	<.001

Predictor	AOR	95% CI	P
Multiple high-risk exposure	2.37	[1.98, 2.84]	<.001

Model Controls: Maternal education, household wealth quintile, residence, region, antenatal care visits, place of delivery, and child sex.

Note. Reference category = No high-risk fertility behaviour.

Table 6 Adjusted Odds Ratios (AOR) for Infant Mortality, Nigeria NDHS 2018 and 2024

Predictor	AOR	95% CI	P
Maternal age <18	1.71	[1.39, 2.11]	<.001
Maternal age ≥35	1.34	[1.15, 1.56]	<.001
Birth order ≥4	1.56	[1.34, 1.81]	<.001
Birth interval <24 months	2.08	[1.80, 2.40]	<.001
Multiple high-risk exposure	2.74	[2.32, 3.24]	<.001

Model Controls: Maternal education, household wealth quintile, residence, region, antenatal care visits, place of delivery, and child sex.

Note. Reference category = No high-risk fertility behaviour

Table 7 Population Attributable Fractions (PAF) for Neonatal and Infant Mortality

Risk Exposure	Neonatal Mortality PAF (%)	Infant Mortality PAF (%)
Maternal age <18	3.1	3.5
Maternal age ≥35	4.0	4.8
Birth order ≥4	8.2	9.4
Birth interval <24 months	14.3	16.7
Multiple high-risk exposure	18.6	21.9
All high-risk combined	32.4	36.8

Note. PAF calculated using adjusted odds ratios and weighted prevalence estimates. Values represent proportion of deaths preventable if exposure were eliminated, assuming causal relationship.