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Burden, Geographic Variation, and Determinants of High-Risk Fertility Behavior Among Women in Bangladesh: Insights from the BDHS 2022

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Abstract

Background

High-risk fertility behavior (HRFB) is a major public health concern associated with adverse maternal and child health outcomes. Despite improvements in reproductive health indicators, HRFB remains prevalent in Bangladesh, and evidence based on the most recent nationally representative data is limited. This study assessed the prevalence, geographical distribution, and determinants of single high-risk fertility behavior (SHRFB) and multiple high-risk fertility behavior (MHRFB) among women in Bangladesh.

Methods

This cross-sectional study utilized data from 8,784 married women aged 15–49 years obtained from the Bangladesh Demographic and Health Survey 2022. HRFB was defined using four fertility-related risk factors: maternal age at birth < 18 years or > 34 years, birth interval < 24 months, and birth order ≥ 4. Women exhibiting one risk factor were classified as having SHRFB, while those with two or more risk factors were categorized as having MHRFB. Descriptive statistics, geographical mapping, and chi-square tests were employed to examine prevalence and bivariate associations. A two level mixed-effects logistic regression models were fitted to identify factors associated with SHRFB and MHRFB, accounting for the hierarchical structure of the survey data.

Results

The prevalence of SHRFB and MHRFB was 23.19% and 4.00%, respectively. SHRFB was most prevalent in Rangpur (25.49%), Mymensingh (24.84%), and Sylhet (24.27%), whereas MHRFB was highest in Sylhet (7.15%) and Mymensingh (7.10%). Women with higher education, ANC utilization, caesarean delivery, and internet use were less likely to experience SHRFB. For MHRFB, higher educational attainment, husband's education, ANC utilization, facility-based delivery, media exposure, internet use, iron supplementation during pregnancy, and caesarean delivery were associated with lower odds. Conversely, rural residence (AOR: 2.16) current employment (AOR: 1.61), history of terminated pregnancy (AOR: 1.94), and higher household wealth were associated with increased odds of MHRFB.

Conclusion

Nearly one-quarter of Bangladeshi women experienced SHRFB, while a smaller yet substantial proportion experienced MHRFB. Significant geographic disparities and socioeconomic inequalities were observed. Strengthening reproductive health education, maternal healthcare utilization, and access to family planning information, particularly in high-burden regions and vulnerable populations, may help reduce HRFB and improve maternal and child health outcomes in Bangladesh.

Background

According to a 2019 global report, approximately 830 women die every day from pregnancy and childbirth-related causes that are largely preventable. Giving birth can be traumatic for women, particularly in developing nations where 99% of maternal deaths take place [1]. Despite a substantial 59% drop in under-five mortality from 93 deaths per 1,000 live births in 1990 to 39 in 2018 child survival remains a global challenge. In 2018 alone, an estimated 5.3 million children still did not live to see their fifth birthday [2]. A pregnancy is generally classified as high-risk when either the mother, the newborn, or both face an elevated likelihood of morbidity or mortality [3, 4]. High risk fertility behaviors (HRFB), characterized by early pregnancies (< 18 years) or late pregnancies (> 34 years) in the reproductive life course, shorter inter-pregnancy intervals (< 24 months), and higher parity (more than two children), are prevalent in low- and middle-income countries (LMICs) [5–9]. In 2023, about 260,000 women died from pregnancy-related causes, mostly in low-income countries and largely preventable [10]. The SDG target aims to reduce global maternal mortality to below 70 per 100,000 by 2030, but the current rate is 197, requiring a nearly 15% annual decline.

Achieving this goal will need much stronger, coordinated efforts worldwide [10]. Although the total fertility rate (TFR) has declined worldwide, the pace of decline in Bangladesh is relatively slow, with a TFR of 2.04 children per woman in 2020, compared to 2.10 in 2010 [11].

Notably, around 41.5% of Bangladeshi women encounter high-risk pregnancies that involve more than one medical complication [12]. Specifically, early or late childbearing and short gaps between births raised the chances of experiencing high-risk pregnancies with multiple complications by roughly 30% and 31%, respectively. Having many previous births increased the risk by 23%, while receiving antenatal care reduced it by 46% [12]. Another cross-sectional study using data from the 2014 Bangladesh Demographic and Health Survey (BDHS) found that 34% of women exhibited high-risk fertility patterns. Of these, 28.7% had one high-risk factor, while 5.4% had multiple high-risk behaviors [7]. Similarly, another study using data from the 2017–18 survey reported an even higher prevalence of high-risk fertility behavior, with 67.7% of women affected. Among them, 45.6% fell into the single high-risk category, while 22.1% had multiple high-risk factors [5]. Alarmingly, teenage pregnancy remains notably high, with about 35% of adolescent girls becoming pregnant, and 15.1% of women giving birth within a short interval of less than 24 months. Compared with many other developing nations, Bangladesh reports one of the highest adolescent fertility levels 82 births per 1,000 girls aged 15–19 in 2019 with more than half of adolescents giving birth during this period [13].

High-risk fertility behaviour in mothers is a biological and demographic factor that can negatively impact a child's health [13]. Findings from numerous studies show that a range of factors contribute to high-risk fertility behaviour. These include whether the pregnancy was intended, limited antenatal care, lack of formal education, non-use of contraception, chronic undernutrition, and economic disadvantage [5, 6, 14, 15]. Several socio-demographic and obstetric factors have been shown to substantially shape women's likelihood of engaging in high-risk fertility behaviors. Evidence indicates that both maternal and paternal education levels [16–19], rural–urban residence [17, 20], household economic status [20, 21], and proximity to or availability of health facilities play influential roles [22]. Utilization of key maternal health services including antenatal care, skilled birth attendance, and contraceptive use [5, 15, 16, 23] also contributes to these patterns. Additionally, a prior history of adverse pregnancy or birth outcomes [16, 21], unwanted pregnancy [5], as well as breastfeeding practices [23, 24], has been identified as important in determining the probability of high-risk fertility behavior.

Despite substantial improvements in maternal and reproductive health in Bangladesh, high-risk fertility behavior remains an important public health concern due to its adverse consequences for maternal and child health outcomes. Although several studies have investigated the prevalence and determinants of HRFB in Bangladesh, most have relied on older BDHS datasets [7, 9, 25–28], particularly the 2011, 2014, and 2017–18 survey rounds. As a result, current evidence may not adequately reflect the contemporary fertility patterns and socio-demographic conditions of Bangladeshi women. Moreover, the recently released Bangladesh Demographic and Health Survey (BDHS) 2022 provides the most up-to-date nationally representative data, yet evidence on the prevalence and determinants of HRFB using this dataset remains limited.

To address this gap, the present study aimed to assess the prevalence, geographical distribution, and determinants of high-risk fertility behavior among women in Bangladesh using data from the BDHS 2022. By utilizing the latest nationally representative survey, this study provides updated evidence on the factors associated with both single and multiple high-risk fertility behaviors, thereby contributing valuable insights for the development of targeted reproductive health policies and interventions in Bangladesh.

Methods

Data Source and Study Design

The study used data from the Bangladesh Demographic and Health Survey. These surveys are carried out by the National Institute of Population Research and Training (NIPORT) under the Ministry of Health and Family Welfare, using a two-stage stratified sampling design. The sampling process involved two main steps. In the first stage, Enumeration Areas (EAs) were selected from the national census database. In the second stage, households were chosen from an updated household list within each selected EA. All data are publicly accessible through the DHS website https://dhsprogram.com/. This analysis used

the most recent BDHS survey 2022 to examine the prevalence and the factors associated with HRFB The study included a total of 8,784 married women aged 15–49 who were not pregnant when the survey was done and had given birth to at least one child before. Detailed information on survey procedures, sampling methods, and data collection can be found in the official BDHS reports [29].

Outcome Variable

The primary outcome of this study was high-risk fertility behavior among women. HRFB was defined according to the standard criteria used in the Demographic and Health Surveys [14, 30–32] and was determined using four recognized fertility-related risk indicators. A woman was classified as experiencing HRFB if her most recent birth met any of the following conditions: (i) she was younger than 18 years at the time of the birth, (ii) 35 years or older at the time of the birth, (iii) the child had a birth order of four or more, (iv) or the birth occurred less than 24 months after the previous one. Women who met only one of the predefined risk criteria were categorized as having single high-risk fertility behavior (SHRFB). In contrast, those who simultaneously exhibited two or more risk conditions were classified as having multiple high-risk fertility behavior (MHRFB). This approach enabled the differentiation between women exposed to a single fertility-related risk factor and those facing multiple overlapping risks, thereby providing a more comprehensive assessment of fertility-related vulnerability.

Independent variables

The study incorporated a range of socio-demographic, economic, and reproductive factors as independent variables. The researchers reviewed the most recent relevant literature to identify and select these variables [14, 27, 31–37]. The list and definitions of the explanatory variables used in the analysis are presented in Table 1

Table 1
List of Explanatory Variables and Their Categories Used in the Analysis

Variables	Categories
Place of residence (residence_v1)	Urban, Rural
Division (v024)	Barishal, Chattogram, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur, Sylhet
Women's education level (edu_level_v3)	No education, Primary, Secondary, Higher
Currently working (current_woking_v4)	No, Yes
Husband's education level (husband_edu_v5)	No education, Primary, Secondary, Higher
ANC visit (anc_visit_v6)	No, Yes
Delivery by caesarean section (caesarean_section_v8)	No, Yes
Place of delivery (delivery_place_v9)	Respondent's home, Other place
Contraceptive use (contraceptive_use_v10)	No, Yes
Media exposure (media_exposure_binary_v16)	No, Yes
Wealth index (wealth_index_v12)	Poorest, Poorer, Middle, Richer, Richest
Internet use (internet_use_v13)	No, Yes
History of terminated pregnancy (terminated_pregnancy_v15)	No, Yes
Contraceptive method (contraceptive_method_v18)	No method, Traditional, Modern
Last birth by caesarean section (last_birth_csection_v17)	No, Yes
Iron supplementation during pregnancy (iron_tablet_preg_v20)	No, Yes

Data Weighting

To improve the accuracy of the multilevel analysis, the standard Demographic and Health Survey sampling weights were adjusted to create distinct weights for individuals (Level-1) and clusters (Level-2). For this, a three-step procedure was used: first, the standard weights were de-normalized to restore the total survey weights; second, cluster-level weights were estimated using the study's sampling design parameters; and third, individual-level weights were calculated by dividing the total weights by the cluster weights [38]. To ensure an equal balance of weight variation between both levels, a scaling parameter (α) was set to 0.5. These adjusted, level-specific weights were then applied to the multilevel mixed-effects logistic regression models to ensure that both fixed and random effects were estimated without bias.

Multilevel Mixed-Effects Logistic Regression Analysis

Because the BDHS data have a hierarchical structure, with women nested within primary sampling units (PSUs), a two-level mixed-effects logistic regression models were fitted to identify factors associated with single high-risk fertility behavior and multiple high-risk fertility behavior. Four models were estimated for each outcome. Model 0 served as a null model, containing no explanatory variables and used to assess the extent of variation attributable to clustering. Model I incorporated individual level characteristics, including maternal education, current working status, number of antenatal care visits, contraceptive method use, history of caesarean delivery, internet use, experience of pregnancy termination, contact and iron tablet intake during pregnancy. Model II included household level characteristics, such as place of residence, husband's education, place of delivery, exposure to media, and household wealth status. Model III represented the full model, combining all individual, and

household-level variables simultaneously. Model performance was evaluated using the log-likelihood, AIC, and BIC. Models with lower AIC and BIC values and higher log-likelihood values were considered to provide a better fit to the data. The model demonstrating the best overall fit was retained for interpretation and reporting of the final results.

Statistical Analysis

Descriptive statistics were used to summarize the distribution of study participants and the prevalence of single high-risk fertility behavior and multiple high-risk fertility behavior. Weighted frequencies and percentages were reported for categorical variables. Bivariate associations between explanatory variables and the outcomes (SHRFB and MHRFB) were assessed using the Rao–Scott adjusted chi-square test, which accounts for the complex survey design. Given the hierarchical structure of the BDHS data, with women nested within primary sampling units (PSUs), A two level mixed-effects logistic regression models with random intercepts were employed separately for SHRFB and MHRFB. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were reported to quantify associations. Model adequacy and clustering effects were evaluated using the intraclass correlation coefficient (ICC), median odds ratio (MOR), PSU-level variance, log-likelihood, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC). Statistical significance was determined at a two-sided p-value < 0.05. All statistical analyses were performed using Stata 17, and graphical representations were created using Python.

Results

Distribution of High-Risk Fertility Behavior

Figure 1 illustrates the distribution of single high-risk fertility behavior and multiple high-risk fertility behavior among women in Bangladesh. The prevalence of SHRFB was substantially higher compared to MHRFB. Approximately 23.19% of women experienced SHRFB, whereas only 4.00% reported MHRFB. Conversely, the majority of women did not experience either SHRFB (76.81%) or MHRFB (96.00%). These findings indicate that single high-risk fertility behavior remains relatively common among Bangladeshi women, while multiple high-risk fertility behavior is comparatively less prevalent.

Bivariate Association Between Explanatory Variables and Single and Multiple High-Risk Fertility Behavior Among Women in Bangladesh

Table 2 presents the bivariate association between explanatory variables and both single high-risk fertility behavior and multiple high-risk fertility behavior among women in Bangladesh. Significant associations were observed for several socio-demographic, reproductive, and household-level factors. The prevalence of SHRFB was significantly higher among rural women (23.92%) compared to urban women (21.23%) (p = 0.01). Women with no education exhibited substantially higher SHRFB prevalence (32.02%) compared to those with higher education (10.56%) (p < 0.001). Similarly, women whose husbands had no education experienced a higher prevalence of SHRFB (26.02%) than those whose husbands had higher education (17.07%) (p < 0.001). Women who did not receive antenatal care (ANC) visits showed a markedly higher prevalence of SHRFB (32.04%) compared to women who received ANC services (21.56%) (p < 0.001). SHRFB prevalence was also higher among women who delivered at home (25.29%), used contraceptives (24.08%), had no internet access (25.60%), lacked media exposure (25.47%), and did not receive iron supplementation during pregnancy (25.06%). Significant associations were additionally observed for wealth index, caesarean delivery status, last birth by caesarean section, and contraceptive method (all p < 0.05). However, women's current working status and history of terminated pregnancy were not significantly associated with SHRFB. Regarding MHRFB, rural women demonstrated a significantly higher prevalence (4.45%) than urban women (2.78%) (p = 0.001). Substantial regional disparities were identified, with the highest prevalence observed in Sylhet (7.15%) and Mymensingh (7.10%), while Khulna exhibited the lowest prevalence (1.80%) (p < 0.001). Women with no education had a markedly higher prevalence of MHRFB (16.89%) compared to women with higher education (0.48%) (p < 0.001). Likewise, MHRFB prevalence declined progressively with increasing husband's educational attainment. Women who did not receive ANC visits had considerably higher MHRFB prevalence (11.32%) than those receiving ANC care (3.36%) (p < 0.001). Elevated prevalence of MHRFB was also identified among women delivering at home (7.12%), women without media exposure (5.69%), women without internet access (5.07%), women with a history of terminated pregnancy (5.89%), and women who did not receive iron supplementation during pregnancy

(8.29%). Significant associations were also observed for contraceptive use, wealth index, caesarean delivery, last birth by caesarean section, and contraceptive method (all $p < 0.001$).

Table 2
Bivariate Association Between Explanatory Variables and Single and Multiple High-Risk Fertility Behavior Among Women in Bangladesh

Variables		Single High-Risk Fertility Behavior (N = 8,784)			Multiple High-Risk Fertility Behavior (N = 8,784)		
	Categories	No	Yes		No	Yes	
		n (%)	n (%)	p-value	n (%)	n (%)	p-value
Place of residence	Urban	1879.52 (78.77)	506.71 (21.23)	0.01	2319.88 (97.22)	66.35 (2.78)	0.001
	Rural	4909.49 (76.08)	1543.38 (23.92)		6165.71 (95.55)	287.17 (4.45)	
Division	Barishal	450.91 (79.12)	118.96 (20.88)	0.47	550.14 (96.54)	19.73 (3.46)	< 0.001
	Chattogram	1488.40 (77.29)	437.28 (22.71)		1829.40 (95.00)	96.28 (5.00)	
	Dhaka	1705.87 (76.98)	510.10 (23.02)		2149.44 (97.00)	66.54 (3.00)	
	Khulna	682.61 (76.92)	204.86 (23.08)		871.45 (98.20)	16.02 (1.80)	
	Mymensingh	563.95 (75.16)	186.38 (24.84)		697.04 (92.90)	53.29 (7.10)	
	Rajshahi	709.96 (78.33)	196.44 (21.67)		881.33 (97.23)	25.07 (2.77)	
	Rangpur	717.05 (74.51)	245.33 (25.49)		930.22 (96.66)	32.17 (3.34)	
	Sylhet	470.27 (75.73)	150.74 (24.27)		576.58 (92.85)	44.43 (7.15)	
Women's education level	No education	372.72 (67.98)	175.58 (32.02)	< 0.001	455.71 (83.11)	92.59 (16.89)	< 0.001
	Primary	1495.37 (72.62)	563.80 (27.38)		1921.98 (93.34)	137.19 (6.66)	
	Secondary	3589.60 (75.68)	1153.52 (24.32)		4626.55 (97.54)	116.57 (2.46)	
	Higher	1331.32 (89.44)	157.20 (10.56)		1481.36 (99.52)	7.16 (0.48)	
Currently working	No	5055.54 (76.93)	1516.16 (23.07)	0.67	6332.74 (96.36)	238.95 (3.64)	0.019
	Yes	1733.48 (76.45)	533.94 (23.55)		2152.85 (94.95)	114.56 (5.05)	
Husband's education level	No education	1026.50 (73.98)	360.98 (26.02)	< 0.001	1242.79 (89.57)	144.69 (10.43)	< 0.001
	Primary	1974.02 (73.79)	701.28 (26.21)		2571.81 (96.13)	103.48 (3.87)	
	Secondary	2342.25 (77.64)	674.57 (22.36)		2932.61 (97.21)	84.21 (2.79)	

Variables		Single High-Risk Fertility Behavior (N = 8,784)			Multiple High-Risk Fertility Behavior (N = 8,784)		
	Categories	No	Yes		No	Yes	
		n (%)	n (%)	p-value	n (%)	n (%)	p-value
	Higher	1345.44 (82.93)	276.96 (17.07)		1602.69 (98.79)	19.71 (1.21)	
ANC visit	No	276.78 (67.96)	130.48 (32.04)	< 0.001	361.17 (88.68)	46.10 (11.32)	< 0.001
	Yes	3702.81 (78.44)	1017.83 (21.56)		4561.92 (96.64)	158.72 (3.36)	
Delivery by caesarean section	No	2292.28 (76.01)	723.36 (23.99)	0.001	2844.32 (94.32)	171.33 (5.68)	< 0.001
	Yes	1908.38 (80.24)	470.08 (19.76)		2334.63 (98.16)	43.84 (1.84)	
Place of delivery	Respondent's home	1458.18 (74.71)	493.73 (25.29)	< 0.001	1812.87 (92.88)	139.04 (7.12)	< 0.001
	Other place	2754.36 (79.74)	699.71 (20.26)		3377.94 (97.80)	76.13 (2.20)	
Contraceptive use	No	2028.07 (78.98)	539.81 (21.02)	0.009	2500.41 (97.37)	67.47 (2.63)	< 0.001
	Yes	4760.94 (75.92)	1510.29 (24.08)		5985.18 (95.44)	286.05 (4.56)	
Wealth index	Poorest	1305.26 (70.58)	544.02 (29.42)	< 0.001	1712.83 (92.62)	136.45 (7.38)	< 0.001
	Poorer	1393.58 (75.85)	443.74 (24.15)		1761.47 (95.87)	75.85 (4.13)	
	Middle	1404.73 (77.17)	415.62 (22.83)		1756.41 (96.49)	63.95 (3.51)	
	Richer	1333.30 (78.38)	367.88 (21.62)		1658.99 (97.52)	42.18 (2.48)	
	Richest	1352.15 (82.90)	278.83 (17.10)		1595.89 (97.85)	35.10 (2.15)	
Internet use	No	4353.04 (74.40)	1497.66 (25.60)	< 0.001	5554.03 (94.93)	296.67 (5.07)	< 0.001
	Yes	2435.97 (81.51)	552.44 (18.49)		2931.56 (98.10)	56.85 (1.90)	
History of terminated pregnancy	No	5365.19 (76.34)	1662.48 (23.66)	0.07	6780.76 (96.49)	246.90 (3.51)	< 0.001
	Yes	1423.82 (78.60)	387.62 (21.40)		1704.83 (94.11)	106.61 (5.89)	
Media exposure	No	2863.99 (74.53)	978.87 (25.47)	< 0.001	3624.09 (94.31)	218.77 (5.69)	< 0.001
	Yes	3925.02 (78.56)	1071.22 (21.44)		4861.50 (97.30)	134.74 (2.70)	

Variables		Single High-Risk Fertility Behavior (N = 8,784)			Multiple High-Risk Fertility Behavior (N = 8,784)		
	Categories	No	Yes		No	Yes	
		n (%)	n (%)	p-value	n (%)	n (%)	p-value
Last birth by caesarean section	No	2612.39 (74.98)	871.85 (25.02)	< 0.001	3297.16 (94.63)	187.08 (5.37)	< 0.001
	Yes	2105.05 (79.80)	532.69 (20.20)		2591.41 (98.24)	46.33 (1.76)	
Contraceptive method	No method	2028.07 (78.98)	539.81 (21.02)	0.03	2500.41 (97.37)	67.47 (2.63)	< 0.001
	Traditional	453.03 (76.82)	136.68 (23.18)		547.83 (92.90)	41.89 (7.10)	
	Modern	4307.91 (75.82)	1373.61 (24.18)		5437.36 (95.70)	244.16 (4.30)	
Iron supplementation during pregnancy	No	775.59 (74.94)	259.40 (25.06)	0.05	949.20 (91.71)	85.78 (8.29)	< 0.001
	Yes	3202.45 (78.27)	888.92 (21.73)		3972.32 (97.09)	119.04 (2.91)	

Values are weighted frequencies and row percentages. P-values were obtained using the Rao–Scott adjusted chi-square test accounting for the complex survey design. SHRFB = Single High-Risk Fertility Behavior and MHRFB = Multiple High-Risk Fertility Behavior. Significant associations were considered at p < 0.05

Geographical Distribution of Single High-Risk Fertility Behavior in Bangladesh

Figure 2 illustrates the geographical distribution of single high-risk fertility behavior among women across the eight divisions of Bangladesh. Noticeable regional variations were observed in the prevalence of SHRFB. Rangpur division recorded the highest prevalence (25.49%), followed by Mymensingh (24.84%) and Sylhet (24.27%). Comparatively high prevalence was also observed in Khulna (23.08%) and Dhaka (23.02%), whereas Chittagong (22.71%) and Rajshahi (21.67%) exhibited relatively lower levels. Barisal reported the lowest prevalence of SHRFB (20.88%).

Geographical Distribution of Multiple High-Risk Fertility Behavior in Bangladesh

Figure 3 presents the geographical distribution of multiple high-risk fertility behavior among women across the divisions of Bangladesh. Substantial regional variation in the prevalence of MHRFB was observed throughout the country. Sylhet division recorded the highest prevalence (7.15%), closely followed by Mymensingh (7.10%). Chittagong also exhibited a relatively high prevalence (5.00%), whereas considerably lower proportions were observed in Barisal (3.46%), Rangpur (3.34%), Dhaka (3.00%), and Rajshahi (2.77%). Khulna reported the lowest prevalence of MHRFB (1.80%).

Model Adequacy and Multilevel Mixed-Effects Analysis of Factors Associated with Single High-Risk Fertility Behavior Among Women in Bangladesh

Table 3 presents the model adequacy statistics for the multilevel mixed-effects logistic regression models examining factors associated with single high-risk fertility behavior (SHRFB) among women in Bangladesh. Among all fitted models, the full model

demonstrated the best fit, as evidenced by the highest log-likelihood (− 13,737.28) and the lowest AIC (27,518.56) and BIC (27,661.93) values, supporting its selection for identifying factors associated with SHRFB.

Table 3
Model Adequacy of Multilevel Mixed-Effects Analysis of Factors Associated with Single High-Risk Fertility Behavior

Parameters	Model 0	Model I	Model II	Model III (Full Model)
Random effect models				
PSU variance (95% CI)	0.63 (0.55–0.73)	1.61 (1.37–1.90)	1.36 (1.15–1.61)	1.61 (1.36–1.90)
ICC (%)	16.10	32.83	29.25	32.83
Model Fitness				
Log-likelihood	-26309.22	-13951.92	-14827.61	-13737.28
AIC	52,622.44	27,927.84	29,679.21	27,518.56
BIC	52,636.60	28,006.17	29,758.08	27,661.93
MOR	2.13	3.35	3.04	3.35
Number of clusters	672	672	672	672

Model 0: Null model; Model I: Adjusted for individual level factors; Model II: Adjusted for household and community level factors; Model III: Fully adjusted model including all covariates. ICC = Intraclass Correlation Coefficient; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; MOR = Median Odds Ratio; PSU = Primary Sampling Unit.

Table 4 presents the results of the multilevel mixed-effects logistic regression analysis (Full Model) examining factors associated with single high-risk fertility behavior among women in Bangladesh. After adjusting for individual, and household-level characteristics, several factors remained significantly associated with SHRFB. Women with higher education were less likely to experience SHRFB compared with women with no formal education (AOR: 0.30, 95% CI: 0.25–0.37, p < 0.001). Similarly, women who received antenatal care (ANC) services were less likely to report SHRFB than those who did not receive ANC (AOR: 0.72, 95% CI: 0.64–0.81, p < 0.001). Women who delivered by caesarean section also had lower odds of SHRFB compared with those who had non-caesarean deliveries (AOR: 0.87, 95% CI: 0.79–0.96, p = 0.004). In contrast, women who used contraceptives were more likely to experience SHRFB than those who did not use contraceptives (AOR: 1.14, 95% CI: 1.06–1.23, p = 0.001). Women whose husbands had attained higher education were also more likely to report SHRFB compared with those whose husbands had no formal education (AOR: 1.30, 95% CI: 1.13–1.50, p < 0.001). Socioeconomic status was also associated with SHRFB. Women from middle-income households (AOR: 0.89, 95% CI: 0.79–0.99, p = 0.033) and richest households (AOR: 0.82, 95% CI: 0.71–0.95, p = 0.007) were less likely to experience SHRFB compared with women from the poorest households. Furthermore, women who used the internet were less likely to report SHRFB than those who did not use the internet (AOR: 0.71, 95% CI: 0.65–0.77, p < 0.001). No statistically significant associations were observed for place of residence, current working status, husband's primary or secondary education, place of delivery, media exposure, history of terminated pregnancy, iron supplementation during pregnancy, or the poorer and richer wealth categories in the adjusted model.

Table 4
Multilevel Mixed-Effects Analysis of Factors Associated with Single High-Risk Fertility Behavior Among Women in Bangladesh (Full Model)

Variables	Categories	AOR	95% CI	p-value
Place of residence	Urban	*Ref*		
	Rural	0.91	0.73–1.13	0.38
Women's education level	No education	*Ref*		
	Primary	1.04	0.90–1.22	0.57
	Secondary	0.96	0.82–1.12	0.59
	Higher	0.30	0.25–0.37	< 0.001***
Currently working	No	*Ref*		
	Yes	0.99	0.92–1.08	0.94
Husband's education level	No education	*Ref*		
	Primary	1.04	0.94–1.16	0.44
	Secondary	0.94	0.84–1.05	0.27
	Higher	1.30	1.13–1.50	< 0.001***
ANC visit	No	*Ref*		
	Yes	0.72	0.64–0.81	< 0.001***
Delivery by caesarean section	No	*Ref*		
	Yes	0.87	0.79–0.96	0.004**
Place of delivery	Respondent's home	*Ref*		
	Other place	0.92	0.84–1.02	0.10
Contraceptive use	No	*Ref*		
	Yes	1.14	1.06–1.23	0.001**
Media exposure	No	*Ref*		
	Yes	0.97	0.90–1.05	0.46
Wealth index	Poorest	*Ref*		
	Poorer	0.92	0.83–1.02	0.10
	Middle	0.89	0.79–0.99	0.033*
	Richer	0.96	0.85–1.08	0.51
	Richest	0.82	0.71–0.95	0.007**
Internet use	No	*Ref*		
	Yes	0.71	0.65–0.77	< 0.001***
History of terminated pregnancy	No	*Ref*		
	Yes	0.97	0.90–1.05	0.49
Iron supplementation during pregnancy	No	*Ref*		
	Yes	1.06	0.98–1.16	0.15

*AOR = Adjusted Odds Ratio; CI = Confidence Interval; Ref = Reference category. Estimates were obtained from Multilevel Mixed-effect logistic regression analysis accounting for the Hierarchical complex survey design. *p < 0.05, **p < 0.01, ***p < 0.001.*

Model Adequacy and Multilevel Mixed-Effects Analysis of Factors Associated with Multiple High-Risk Fertility Behavior Among Women in Bangladesh

Table 5 presents the model adequacy statistics for the multilevel mixed-effects logistic regression models assessing factors associated with multiple high-risk fertility behavior (MHRFB) among women in Bangladesh. Among all fitted models, the full model exhibited the best overall fit, as indicated by the highest log-likelihood (– 3319.27) and the lowest AIC (6682.54) and BIC (6825.91) values. These findings support the use of a multilevel modeling approach and confirm the superiority of the full model for identifying determinants of MHRFB among Bangladeshi women.

Table 5
Model Adequacy of Multilevel Mixed-Effects Analysis of Factors Associated with Multiple High-Risk Fertility Behavior

Parameters	Model 0	Model I	Model II	Model III (Full Model)
Random effect models				
PSU variance (95% CI)	8.03 (6.26–10.29)	13.04 (9.46–17.99)	11.65 (8.44–16.09)	13.26 (9.60–18.31)
ICC (%)	70.93	79.86	77.98	80.12
Model Fitness				
Log-likelihood	-7332.70	-3420.96	-3836.06	-3319.27
AIC	14,669.39	6,865.91	7,696.12	6,682.54
BIC	14,683.55	6,944.24	7,774.99	6,825.91
MOR	14.92	31.32	25.65	32.24
Number of clusters	672	672	672	672

Model 0: Null model; Model I: Adjusted for individual level factors; Model II: Adjusted for household and community level factors; Model III: Fully adjusted model including all covariates. ICC = Intraclass Correlation Coefficient; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; MOR = Median Odds Ratio; PSU = Primary Sampling Unit.

Table 6 presents the results of the multilevel mixed-effects logistic regression analysis (Full Model) examining factors associated with multiple high-risk fertility behavior among women in Bangladesh. After adjusting for individual, and household-level characteristics, several factors were significantly associated with MHRFB. Women residing in rural areas were more likely to experience MHRFB than their urban counterparts (AOR: 2.16, 95% CI: 1.14–4.09, p = 0.019). Educational attainment showed a strong inverse association with MHRFB. Compared with women with no formal education, those with primary (AOR: 0.32, 95% CI: 0.26–0.41), secondary (AOR: 0.15, 95% CI: 0.11–0.19), and higher education (AOR: 0.02, 95% CI: 0.01–0.03) were less likely to report MHRFB (all p < 0.001). Similarly, women whose husbands had primary, secondary, and higher education were less likely to experience MHRFB than those whose husbands had no formal education. Currently working women were more likely to report MHRFB compared with non-working women (AOR: 1.61, 95% CI: 1.35–1.93, p < 0.001). In contrast, women who received antenatal care (ANC) services were less likely to experience MHRFB than those who did not receive ANC (AOR: 0.56, 95% CI: 0.45–0.69, p < 0.001). Likewise, women who delivered by caesarean section (AOR: 0.67, 95% CI: 0.52–0.87, p = 0.002) and those who delivered at a health facility or other locations outside the home (AOR: 0.68, 95% CI: 0.54–0.85, p = 0.001) were less likely to report MHRFB. Women with media exposure were less likely to experience MHRFB compared with those without media exposure (AOR: 0.72, 95% CI: 0.60–0.87, p < 0.001). Similarly, internet users were less likely to report MHRFB than non-users (AOR: 0.47, 95% CI: 0.37–0.60, p < 0.001). Women who received iron supplementation during pregnancy were also less likely to experience MHRFB (AOR: 0.47, 95% CI: 0.40–0.57, p < 0.001). Household wealth demonstrated a mixed relationship with MHRFB. Compared with women from the poorest households, those from richer (AOR: 1.90, 95% CI: 1.41–2.54, p < 0.001) and richest households (AOR: 4.43, 95% CI: 3.10–6.32, p < 0.001) were more likely to report MHRFB. Furthermore, women with a

history of terminated pregnancy were nearly twice as likely to experience MHRFB as those without such a history (AOR: 1.94, 95% CI: 1.63–2.30, $p < 0.001$). No statistically significant associations were observed for contraceptive use, or for women in the poorer and middle wealth categories, after adjustment for other covariates.

Table 6
Multilevel Mixed-Effects Analysis of Factors Associated with Multiple High-Risk Fertility Behavior Among Women in Bangladesh (Full Model)

Variables	Categories	AOR	95% CI	p-value
Place of residence	Urban	*Ref*		
	Rural	2.16	1.14–4.09	0.019*
Women's education level	No education	*Ref*		
	Primary	0.32	0.26–0.41	< 0.001***
	Secondary	0.15	0.11–0.19	< 0.001***
	Higher	0.02	0.01–0.03	< 0.001***
Currently working	No	*Ref*		
	Yes	1.61	1.35–1.93	< 0.001***
Husband's education level	No education	*Ref*		
	Primary	0.60	0.49–0.72	< 0.001***
	Secondary	0.52	0.41–0.66	< 0.001***
	Higher	0.65	0.45–0.94	0.023*
ANC visit	No	*Ref*		
	Yes	0.56	0.45–0.69	< 0.001***
Delivery by caesarean section	No	*Ref*		
	Yes	0.67	0.52–0.87	0.002**
Place of delivery	Respondent's home	*Ref*		
	Other place	0.68	0.54–0.85	0.001**
Contraceptive use	No	*Ref*		
	Yes	1.13	0.95–1.35	0.177
Media exposure	No	*Ref*		
	Yes	0.72	0.60–0.87	< 0.001***
Wealth index	Poorest	*Ref*		
	Poorer	0.81	0.66–1.01	0.060
	Middle	0.99	0.77–1.26	0.914
	Richer	1.90	1.41–2.54	< 0.001***
	Richest	4.43	3.10–6.32	< 0.001***
Internet use	No	*Ref*		
	Yes	0.47	0.37–0.60	< 0.001***
History of terminated pregnancy	No	*Ref*		
	Yes	1.94	1.63–2.30	< 0.001***
Iron supplementation during pregnancy	No	*Ref*		
	Yes	0.47	0.40–0.57	< 0.001***

*AOR = Adjusted Odds Ratio; CI = Confidence Interval; Ref = Reference category. Estimates were obtained from Multilevel Mixed-effect logistic regression analysis accounting for the Hierarchical complex survey design. *p < 0.05, **p < 0.01, ***p < 0.001.*

Discussion

The findings revealed that single high-risk fertility behavior was considerably more prevalent than multiple high-risk fertility behavior among women in Bangladesh, affecting 23.19% and 4.00% of women, respectively. Significant geographical disparities were observed, with SHRFB being most prevalent in Rangpur, Mymensingh, and Sylhet divisions, while MHRFB was concentrated in Sylhet and Mymensingh. Educational attainment emerged as one of the strongest protective factors against both SHRFB and MHRFB. Women with higher education, those who received antenatal care (ANC), women who delivered by caesarean section, and internet users were less likely to experience high-risk fertility behaviors. For MHRFB specifically, media exposure, facility-based delivery, husband's education, and iron supplementation during pregnancy were also less likely of experiencing multiple fertility risks. Conversely, rural residence, current employment, history of terminated pregnancy, and higher household wealth were less likely of experiencing MHRFB.

In this study, nearly one-quarter (23.2%) of Bangladeshi women exhibited a single high-risk fertility behavior, whereas 4.0% experienced multiple high-risk fertility behaviors. These estimates closely align with the BDHS 2022 findings, which indicated that 23% of women were classified within a single high-risk fertility category and 4% within multiple high-risk fertility categories, thereby supporting the validity of the present results [29]. Compared with the 2017–18 BDHS, which documented a higher prevalence of SHRFB (28%) but a similar prevalence of MHRFB (4%), the current findings suggest a modest decline in single high-risk fertility behavior over time while multiple high-risk fertility behavior has remained relatively unchanged [39]. Although the prevalence remains substantial, it is comparatively higher than estimates reported in several South Asian contexts. For example, approximately 32% of women in India [40] exhibited at least one form of high-risk fertility behavior in 2015–16, while about 38% of married women in Nepal [41] were classified within at least one high-risk fertility category in 2011. The observed decline in high-risk fertility behavior in Bangladesh likely reflects ongoing reductions in fertility rates and improvements in family planning services. Nevertheless, nearly one-quarter of women continue to be exposed to at least one fertility-related risk. This progress may also be attributable to large-scale interventions, including programs that reached more than two million adolescent girls and successfully delayed marriage, increased contraceptive use, and reduced fertility in a cost-effective manner [42, 43].

Notably, the present study found marked geographic variation: SHRFB was most prevalent in Rangpur, Mymensingh and Sylhet, while MHRFB clustered in Sylhet and Mymensingh. The particularly high prevalence observed in Sylhet Division may be attributed to persistently low utilization of modern contraceptive methods and a substantial unmet need for family planning services, compounded by regional demographic characteristics such as early marriage and childbearing, as well as prevailing sociocultural norms that influence reproductive behavior [44]. The higher prevalence of HRFB in Rangpur may be associated with its relatively remote geographic location, limited utilization of reproductive health services, including antenatal care (ANC), low adoption of family planning methods influenced by religious beliefs and community attitudes, and comparatively lower levels of educational attainment and literacy [45]. However, another study reported that the prevalence of non-use of modern contraceptive methods a key determinant of high-risk fertility behavior was highest in the Sylhet, Barishal, and parts of the Chattogram divisions [46].

The study further suggests women with higher education, those who received antenatal care (ANC), women who delivered by caesarean section, and internet users were less likely to experience high-risk fertility behaviors. This finding is consistent with previous evidence indicating that education and access to health information and maternal healthcare services play a crucial role in reducing risky reproductive practices. For example, a study conducted in Nigeria reported that HRFB was significantly more prevalent among women with low levels of education (73.6%) and those residing in rural areas (67.0%), highlighting the disproportionate burden of HRFB among socioeconomically disadvantaged populations [47]. Similarly, a study from Sub-Saharan Africa found that women with no formal education or only primary-level schooling, as well as those whose husbands had low educational attainment, were at a significantly higher risk of engaging in high-risk fertility behaviors [17]. Women who attended four or more antenatal care visits had a 20% lower relative risk of experiencing multiple high-risk fertility behaviors,

suggesting that adequate ANC utilization serves as a protective factor. Similarly, women who delivered by caesarean section exhibited a 43% lower relative risk of engaging in multiple high-risk fertility behaviors compared with those who had non-caesarean deliveries [33]. These findings may be attributed to the fact that educated women generally have greater knowledge and awareness of reproductive health, reducing their likelihood of engaging in high-risk fertility behaviors. Conversely, limited education may hinder appropriate maternal healthcare utilization, including ANC attendance. ANC visits provide essential health information and counseling, increasing awareness of the risks associated with HRFB and promoting safer reproductive practices [45].

The present study further suggests that, specifically for multiple high-risk fertility behaviors, women with media exposure, those who delivered in health facilities, those whose husbands had higher educational attainment, and those who received iron supplementation during pregnancy were less likely to experience multiple fertility risks. Evidence from Ethiopia supports this pattern, showing that having access to television or radio was associated with a 35% reduction in the likelihood of engaging in high-risk fertility behavior compared with women who lacked media access [48]. These findings align with the observation that limited media exposure tends to concentrate high-risk fertility behaviors among disadvantaged groups. Similarly, another study in Nigeria found that women with media exposure experienced a 12% reduction in the odds of high-risk fertility behavior compared with those who were not exposed [47]. Women whose husbands had secondary or higher education were less likely to exhibit multiple high-risk fertility behaviors compared with those whose husbands had no formal education. Similarly, facility-based delivery may reduce the likelihood of high-risk fertility behaviors by increasing women's access to maternal health services, health education, and family planning information. These findings suggest that both spousal education and healthcare utilization play important roles in promoting safer reproductive behaviors [32, 49, 50]. Although a study conducted in Sub-Saharan Africa identified low community-level women's empowerment, early and polygamous marriages, poor household wealth status, unmet need for contraception, and rural residence as significant factors associated with high-risk fertility behaviors, our findings highlight the additional protective roles of education, healthcare utilization, and access to health information in reducing fertility-related risks [17].

Additionally, rural residence, current employment status, a history of terminated pregnancy, and higher household wealth were more likely of experiencing multiple high-risk fertility behaviors. Consistent with the present findings, a study conducted in Kenya reported that women with a history of terminated pregnancy were more likely to experience high-risk fertility behavior. The study further found that women residing in rural areas were 1.26 times more likely to engage in high-risk fertility behavior than those living in urban areas, while women from wealthier households were also more likely to experience high-risk fertility behavior [51]. Similarly, another study reported that women living in better socioeconomic conditions, classified as wealthy women, had a 1.10-fold higher likelihood of engaging in high-risk fertility behavior compared with women from poorer households. The same study also identified a history of abortion as a significant factor associated with an increased likelihood of high-risk fertility practices [16]. The higher prevalence of high-risk fertility behaviors among rural women may be attributed to limited access to healthcare facilities, reproductive health information, and family planning services compared with the urban women [16]. Women from wealthier households may be less likely to engage in high-risk fertility behaviors because greater economic resources facilitate better access to healthcare services, reproductive health information, and family planning methods, thereby supporting safer reproductive decision-making [50]. Furthermore, the higher likelihood of multiple high-risk fertility behaviors among employed women may be partly explained by differences in their demographic, socioeconomic, and reproductive characteristics. Employed women often have distinct reproductive histories, including a greater prevalence of previous pregnancy losses such as stillbirths and miscarriages, which may contribute to an increased likelihood of experiencing high-risk fertility behaviors [52].

Strengths of the Study

This study has several important strengths. First, it utilized data from the Bangladesh Demographic and Health Survey 2022, the most recent nationally representative survey available, ensuring that the findings reflect the current fertility patterns and reproductive health conditions of women in Bangladesh. Second, the large sample size and rigorous sampling design enhance the generalizability of the findings to the national population of reproductive-aged women. Third, unlike many previous studies that focused solely on overall high-risk fertility behavior, this study separately examined single high-risk fertility behavior and

multiple high-risk fertility behavior, providing a more nuanced understanding of fertility-related risks. Fourth, the use of multilevel mixed-effects logistic regression accounted for the hierarchical structure of the BDHS data and clustering at the community level, thereby improving the accuracy and reliability of the estimated associations. Finally, the inclusion of geographical distribution analyses enabled the identification of regional disparities in HRFB, providing valuable evidence for designing targeted reproductive health interventions and policies.

Limitations of the Study

Despite its strengths, this study has several limitations. First, the cross-sectional nature of the BDHS data precludes the establishment of causal relationships between the identified factors and high-risk fertility behaviors. Second, information on reproductive history, contraceptive use, and maternal healthcare utilization was self-reported and may therefore be subject to recall bias or social desirability bias. Third, several potentially important determinants of fertility behavior, such as cultural norms, women's autonomy in household decision-making, quality of healthcare services, community-level family planning availability, and partner-related behavioral factors, were not available in the BDHS dataset and could not be included in the analysis. Fourth, HRFB was assessed based on the most recent birth and may not fully capture women's lifetime fertility experiences.

Conclusion

High-risk fertility behavior remains a significant public health concern among women in Bangladesh, with nearly one in four women experiencing a single high-risk fertility behavior and a smaller but important proportion experiencing multiple high-risk fertility behaviors. Substantial geographic disparities were observed, with the burden of HRFB being particularly concentrated in the Rangpur, Mymensingh, and Sylhet divisions. Educational attainment, antenatal care utilization, caesarean delivery, internet use, media exposure, facility-based delivery, husband’s education, and iron supplementation during pregnancy were identified as important protective factors against HRFB. In contrast, rural residence, current employment, a history of terminated pregnancy, and higher household wealth were associated with an increased likelihood of multiple high-risk fertility behaviors. These findings highlight the importance of strengthening reproductive health education, expanding access to quality maternal healthcare and family planning services, and improving the dissemination of reproductive health information through both traditional and digital platforms. Targeted interventions focusing on women with limited educational attainment, those residing in rural areas, and regions with a disproportionately high burden of HRFB are essential to reduce fertility-related risks and improve maternal and child health outcomes. Continued efforts to promote informed reproductive decision-making and equitable access to maternal health services will be critical for accelerating progress toward national and global maternal and child health goals.

Abbreviations

Abbreviation	Full Form
AIC	Akaike Information Criterion
ANC	Antenatal Care
AOR	Adjusted Odds Ratio
BDHS	Bangladesh Demographic and Health Survey
BIC	Bayesian Information Criterion
CI	Confidence Interval
DHS	Demographic and Health Survey
EA	Enumeration Area
HRFB	High-Risk Fertility Behavior
ICC	Intraclass Correlation Coefficient
LMICs	Low- and Middle-Income Countries
MHRFB	Multiple High-Risk Fertility Behavior
MOR	Median Odds Ratio
NIPORT	National Institute of Population Research and Training
PSU	Primary Sampling Unit
SDG	Sustainable Development Goal
SHRFB	Single High-Risk Fertility Behavior
TFR	Total Fertility Rate

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for Publication

Not applicable.

Availability of Data and Materials

The datasets used in this study were sourced from the Demographic and Health Surveys (DHS) program, which are publicly available at https://dhsprogram.com/data/ The specific data analyzed in this research is available from the corresponding author upon reasonable request.

Competing interests

The authors declare no competing interests.

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Author Contribution Statement

MJU, MSH and MRH conceptualized and designed the study. MRH and DA carried out the data cleaning, and MRH performed the statistical analysis. MRH and DA drafted the manuscript, with MRH organizing and structuring the paper in its entirety. MSH and MJU provided critical intellectual input and contributed to the revision and refinement of the manuscript. All authors reviewed and approved the final version.

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Figures

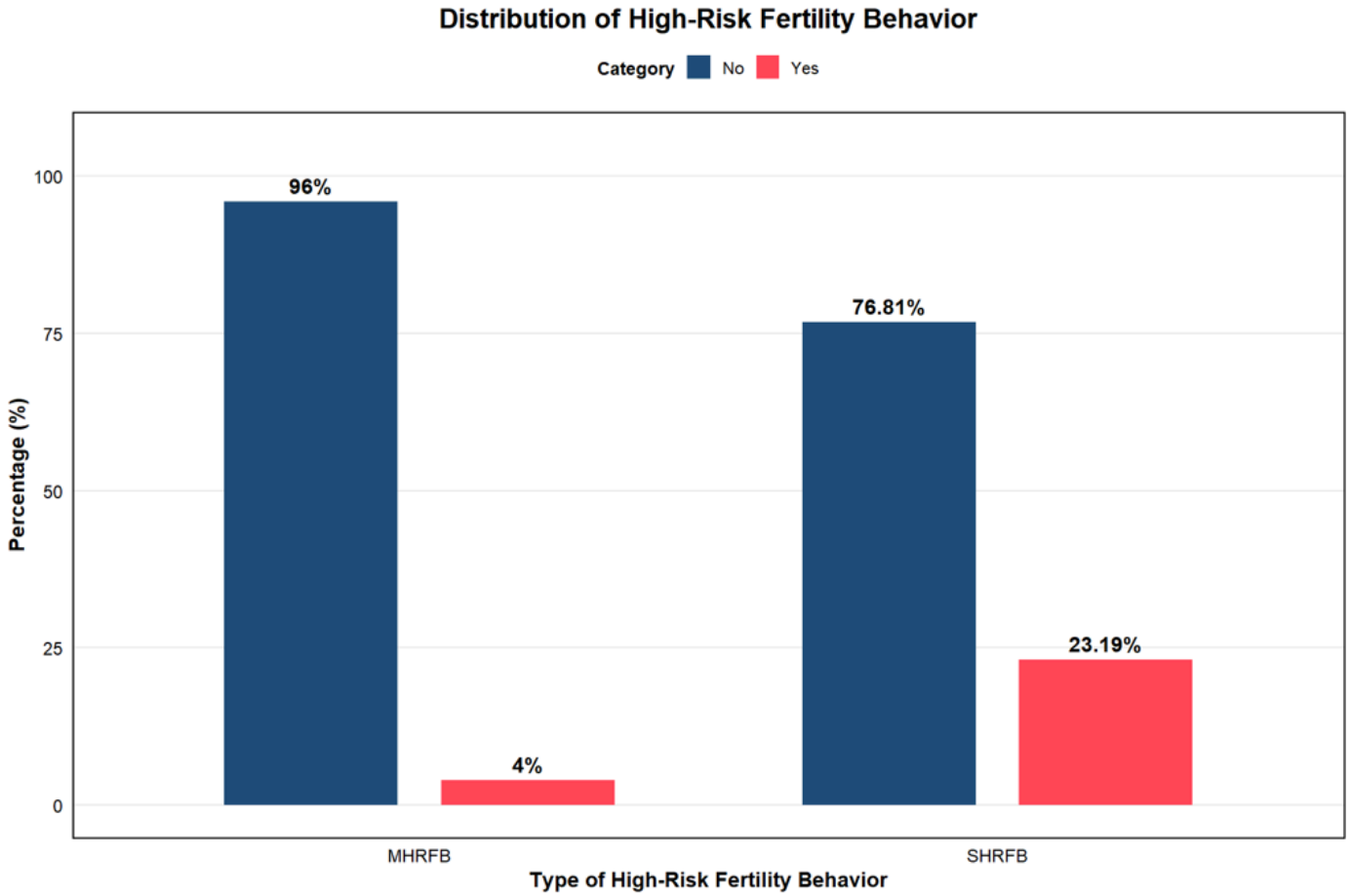


Figure 1

Distribution of High-Risk Fertility Behavior

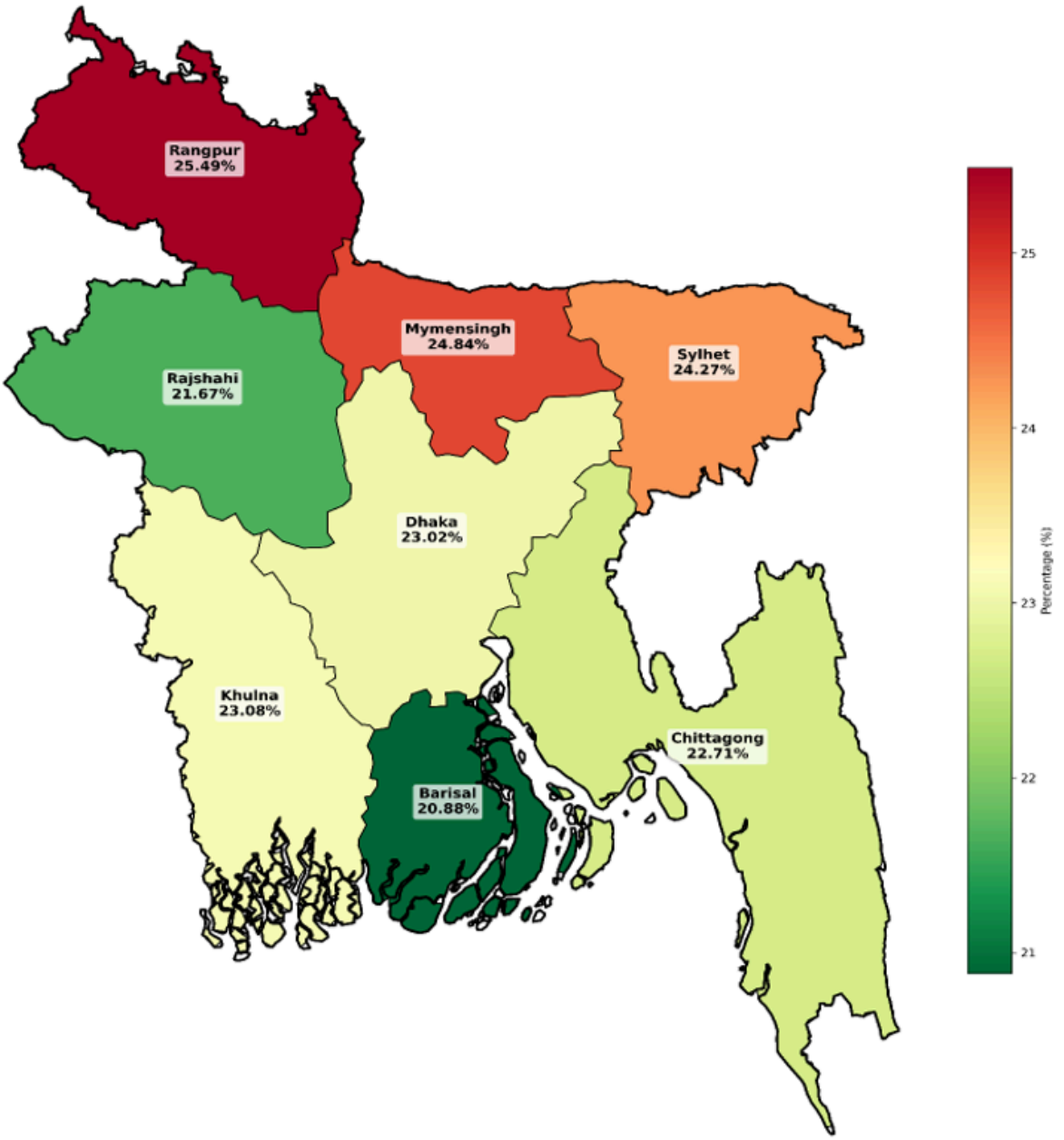


Figure 2

Geographical Distribution of Single High-Risk Fertility Behavior in Bangladesh

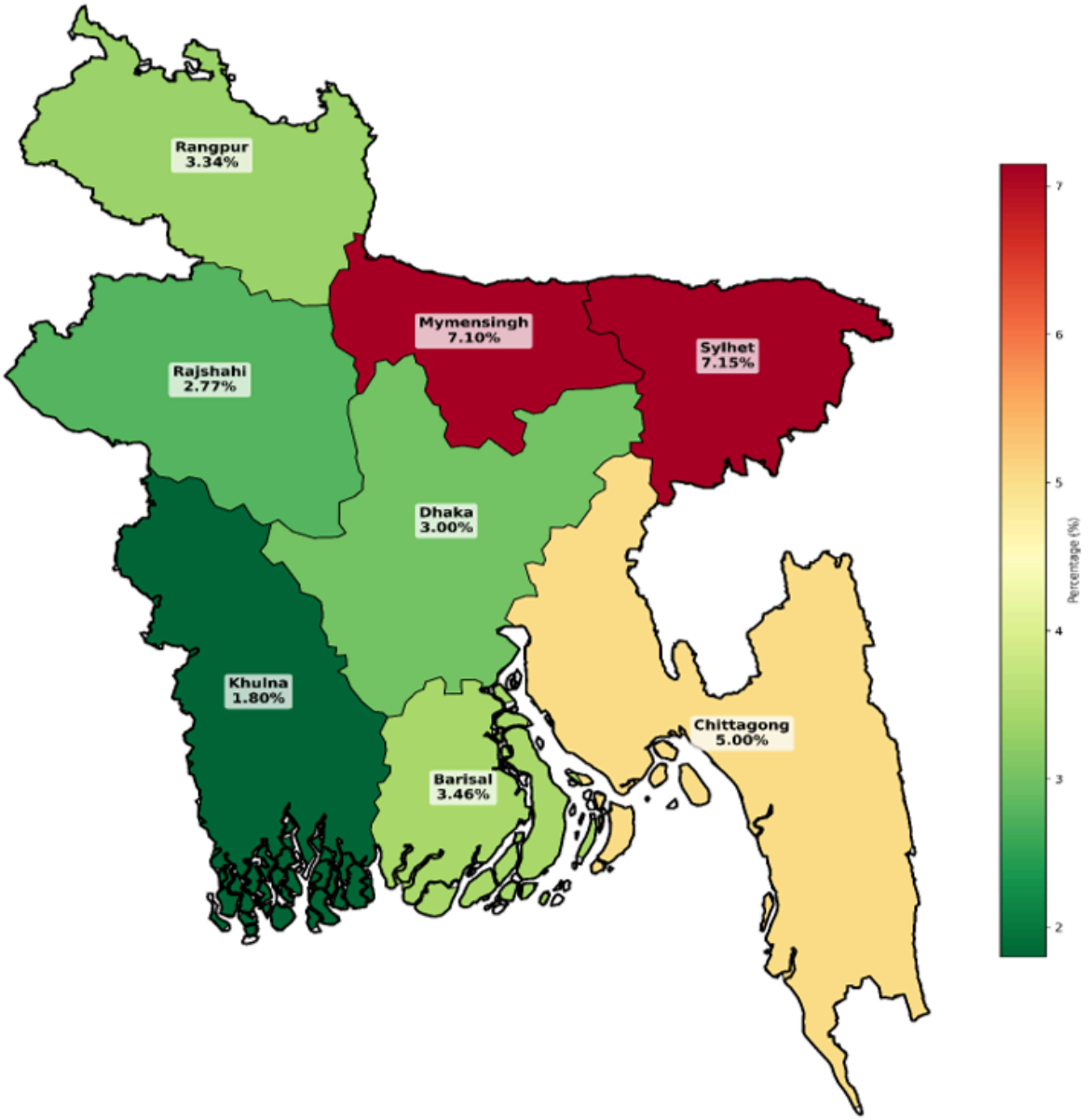


Figure 3

Geographical Distribution of Multiple High-Risk Fertility Behavior in Bangladesh