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Trends and associated factors of Premature or Early Menopause Among Bangladeshi Women: a repeated cross-sectional analysis of six Bangladesh Demographic and Health Surveys

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Abstract

Objective

Premature menopause (PM; menopause before age 40) and early menopause (EM; menopause at ages 40–44) are associated with increased risks of cardiovascular disease, osteoporosis, adverse psychosocial outcomes, and many other long-term illnesses. Despite Bangladesh's rapid demographic and fertility transitions, national evidence on PM and EM remains limited. This study examined trends and associated factors of PM or EM among Bangladeshi women over the past two decades.

Methods

We analyzed data from six rounds (2004–2022) of the Bangladesh Demographic and Health Survey, including 41,697 ever-married women aged 30–44 years. The outcome variable was premature or early menopause (PM/EM) was defined as menopause before age 45 years, based on ≥ 6 months (according to DHS) of amenorrhea (excluding pregnancy and postpartum amenorrhea) or self-reported menopause/hysterectomy. Weighted prevalence estimates were calculated across survey years. Multivariable logistic regression models were used to identify associated factors.

Results

PM/EM prevalence increased between 2004 and 2014 and subsequently declined by 2022 (2004: 10.0% to 2014: 14.9% to 2022: 11.0%), although level remains substantial. PM (6.5% to 10.0% to 6.7%) and EM (19.3% to 26.1% to 22.5%) prevalence individually followed the same pattern. Adolescent first birth showed consistently significant association PM/EM over time (AOR in 2004: 0.97; in 2022: 0.60). Contraceptive use and higher educational attainment were associated with lower odds of PM/EM.

Conclusions

PM/EM remains a public health concern in Bangladesh. Persistent disparities by education and birth history highlight the importance of policies promoting female education and delaying early marriage and childbearing to reduce early reproductive aging and long-term health risks.

Background

Menopause refers to the irreversible cessation of menstruation resulting from the loss of ovarian follicular activity, and therefore marks the end of the woman’s reproductive ability (1). Although globally the average age of natural menopause typically falls between the mid-forties and mid-fifties (around 45–55 years), there is a distinct cohort of women who display an early onset of menopausal transition(1, 2). Premature menopause (PM) occurs before age 40 years, and early menopause (EM) between 40–44 years (1). PM and EM have cascading implications for non-communicable disease (NCD) burden by doubling risks of cardiovascular disease, osteoporosis, and type 2 diabetes, while extending morbidity by 10–15 years (3). These early transitions also elevate chances of cognitive decline, depression, all-cause mortality, and long-term metabolic/psychosocial effects from hormonal changes (4).

Globally, the age at menopause and its prevalence vary considerably across populations and regions. Evidence indicates that women in low- and middle-income countries (LMICs) tend to reach menopause at younger ages than those in high-income settings (5). In South and Southeast Asia, over 15% of women experience early menopause, while approximately 4% undergo premature menopause (6, 7). National-level studies of India have reported a relatively stable trend of prevalence of menopausal women over time and among these women, the estimated prevalence of premature menopause is 2.2%, while that of early menopause is 16.2% with a slowly decreasing trend (8, 9). The reported prevalence of PM varies from 1.58% to 6.87% in LMICs with geographic variations. Country-specific trajectories may diverge based on distinct socioeconomic transitions, health system investments, and policy interventions (7). Bangladesh may exhibit distinct patterns of menopausal timing due to its rapid demographic and reproductive transitions over the past two decades.

Determinants of menopausal timing have been assessed on a global scale, with consistent evidence showing that education, socioeconomic condition, smoking, body mass index, parity and age at first birth are significant predictors of early menopausal timing (2, 10). In LMIC contexts, early childbearing, poor nutrition, and reproductive stressors are key contributors to earlier menopause (9). However, the onsets of menopause seem to vary by race and ethnicity and are affected by demographic and lifestyle factors (11).

Despite rapid socioeconomic transformation and improvements in women's health in Bangladesh over the past two decades; including total fertility decline from 5.5 (1985) to 2.1, rising female education, and declining maternal undernutrition (12); comprehensive national evidence on premature and early menopause remains absent. Existing Bangladesh research has focused on overall menopause age in small clinical samples or cross-sectional surveys without distinguishing PM or EM, limiting understanding of these distinct public health concerns (13–18). Critically, no nationally representative studies have examined how PM/EM trends have evolved over time as Bangladesh's demographic transition progressed, nor whether established determinants have changed in strength or direction as fertility patterns shifted. This knowledge gap has two important implications: First, reproductive health programs are not necessarily designed to prevent PM/EM and without trend data, policy-makers cannot assess whether reproductive health investments are succeeding in preventing early reproductive aging. Second, without analysis of determinant effects, interventions may target risk factors whose population-level importance has diminished. Given the increasing burden of non-communicable diseases in Bangladesh, understanding patterns of early reproductive aging is important for anticipating future health risks among women. Therefore, this study aims to estimate the trends and associated factors of premature or early menopause among Bangladeshi women in the past two decades.

Methods

Study design and data sources

This study employed a repeated cross-sectional design using nationally representative data from six rounds of the Bangladesh Demographic and Health Surveys (BDHS) conducted in 2004, 2007, 2011, 2014, 2017–18, and 2022 (19–24). These surveys are part of the global DHS program, implemented by the National Institute of Population Research and Training (NIPORT) with technical assistance from ICF International. The BDHS applies a two-stage stratified cluster sampling design, ensuring representation of both urban and rural populations across all administrative divisions. We managed, and combined the data from the website (www.dhsprogram.com) and analyzed for our study. Each survey round obtained written informed consent from participants before conducting the survey.

Study population

The analytic sample comprised ever-married women aged 30–44 years, a demographic bracket that encompasses individuals at risk for premature or early menopause. To minimize the misclassification due to uncertainty of reproductive transitions, women > 44 years were excluded, as many of them reported menopausal statuses without timing of last menses, precluding determination of early/premature onset. Women younger than 30 years were excluded because menopause before this age is extremely rare and often pathological (25). Women who were currently pregnant or experiencing postpartum amenorrhea were considered as not menopaused. After applying eligibility criteria, the final analytic sample comprised 41,697 women across all six survey rounds.

Measures

Outcome variable

The BDHS followed standard definition of menopause, where If a woman's most recent menstrual period occurred 6 or more months before the survey, she is neither pregnant nor postpartum amenorrhoeic, or if she declared she is in menopause or has had a hysterectomy was classified as menopausal (19). The primary outcome was premature or early menopause according to DHS-defined menopausal status, and the age range of premature or early menopause defined according to World Health Organization criteria (1).

- Premature menopause (PM): permanent cessation of menstruation among 30–39 years old women.
- Early menopause (EM): permanent cessation of menstruation among 40–44 years old women.

A binary variable was also constructed combining PM and EM to indicate whether a woman between 30–44 years, had experienced premature or early menopause (PM/EM) (1 = yes, 0 = no) for identifying associated factors.

Explanatory variables

Covariates were selected based on theoretical relevance and prior empirical evidence linking them to menopausal timing (2, 9, 18, 26, 27). These included a range of sociodemographic, socioeconomic, and reproductive characteristics. Sociodemographic factors comprised age (30–34, 35–39, and 40–44 years), place of residence (urban or rural), and educational attainment (no education, primary, secondary, and higher). Socioeconomic status was assessed through the household wealth index, categorized from the poorest to the richest quintile, and current employment status (employed or unemployed). Women's empowerment was measured using composite indicators of household decision-making autonomy and attitudes toward wife beating. Higher decision-making autonomy and lower acceptance of wife beating reflected greater empowerment. A binary empowerment variable (yes/no) was derived from decision-making autonomy which was not available in 2004 and 2007 survey round. Reproductive factors included age at first birth (adolescent < 20 years versus adult ≥ 20 years), age at last birth (≤ 19, 20–30, and > 30 years), number of children (0, 1–2, 3–4, and > 4), and ever use of contraception (yes or no). Nutritional status was determined by Body Mass Index (BMI), categorized as underweight (< 18.5 kg/m²), normal (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), and obese (≥ 30 kg/m²) (28).

Statistical analysis

All analyses were carried out with Stata version 15. Before analysis, missing observations were removed (Fig. 1). Descriptive statistics including frequencies and proportions were used to characterize sociodemographic and reproductive variables. Prevalence estimates were calculated and multivariable logistic regression models were fitted separately for each survey round. Weighted prevalence estimates of PM and EM were calculated for each round of the survey in order to determine trends, and cross-tabulations were conducted to investigate prevalence across independent variables. Associations between PM/EM (binary outcome: yes/no) and explanatory variables were assessed with separate multivariable logistic regressions for each survey round. In the regression analysis, nulliparous women were excluded to avoid potential distortion arising from the inclusion of the "Age at first birth" variable. Statistical significance was established by using two-tailed tests at the level of $p < 0.05$ and 95% confidence intervals. Sampling weights were used to adjust for unequal selection probabilities and to provide national representativeness.

Use of Artificial Intelligence

Generative artificial intelligence (AI) tools, including ChatGPT, Perplexity, and Elicit, were used to assist in drafting and refining the discussion section. All AI-generated contents were critically reviewed, edited, and verified.

Results

Figure 2 elicits national trends in PM, EM and PM/EM spanning the period from 2004 to 2022. Overall, the combined prevalence of PM/EM among women aged 30–44 years increased from approximately one in ten women in the earlier survey rounds to nearly one in six in 2014 before declining again by 2022. The prevalence of PM among 30–39 years old women increased from 6.5% in 2004 to a peak of 10.0% in 2014 and then declined to 6.7% in 2022. An almost parallel trajectory was also observed for EM among 40–44 years old women, which went from 19.3% in 2004 to 26.1% in 2014 and then dropped to 22.5% in 2022. Across all survey years, EM prevalence was consistently higher than PM prevalence two to four times. Age-specific estimates of prevalence for PM and EM are shown in **Supplementary Fig. 1**.

Table 1 shows the weighted prevalence of PM or EM, according to socioeconomic, demographic, and reproductive characteristics from 2004 to 2022. There were significant disparities on several dimensions. Educational attainment was a consistent determinant across all survey years, with women who have no formal education having consistently higher prevalence than those with secondary/higher education. While overall prevalence has declined since 2014, the educational gap has remained constant up to 2022, with an upward trend in prevalence among women who were uneducated. Reproductive factors showed a strong relationship with PM or EM prevalence. Women with the first birth in adolescence (< 20 years) consistently had higher prevalence than those with the first births in adulthood (> 20 years). Women having 1–2 child always demonstrated lowest prevalence than women having no children or have more than 4 children. Similarly, women who had never used contraception had higher prevalence than ever-users across all survey rounds, with differences exceeding 10 percentage points in several years. Socioeconomic disparities based on household wealth index existed but were not as pronounced. Urban- rural differences were small with slightly higher prevalence in rural areas. Nutritional status also affected the prevalence: underweight women showed a higher prevalence of PM or EM, especially in the latter rounds of the survey, while the difference between the other groups of normal weight, overweight and obese women was smaller.

Table 1
Prevalence of PM or EM by socio-demographic, economic and reproductive characteristics in Bangladesh fr

Variables	2004			2007			2011			2014		
	n/N	%	p-value	n/N	%	p-value	n/N	%	p-value	n/N	%	p-value
Residence												
Urban	160/1584	10.1	0.915	214/1764	12.1	0.55	293/2533	11.6	0.06	352/2643	13.3	< 0.001a
Rural	289/2864	10.1		309/2711	11.4		615/4614	13.3		772/4879	15.8	
Level of education												
No education	245/2204	11.1	0.092	265/1926	13.8	< 0.001[a]	409/2601	15.7	< 0.001[a]	507/2526	20.1	< 0.001[a]
Primary	108/1252	8.6		170/1321	12.9		307/2199	14.0		372/2348	15.8	
Secondary	77/765	10.1		74/876	8.4		173/1707	10.1		213/2015	10.6	
Higher	19/227	8.4		14/352	4.0		19/640	3.0		32/633	5.1	
Wealth index												
Poorest	67/774	8.7	0.271	75/728	10.3	0.019[a]	164/1189	13.8	< 0.001[a]	213/1320	16.1	< 0.001[a]
Poorer	70/755	9.3		95/795	11.9		192/1334	14.4		254/1470	17.3	
Middle	91/813	11.2		106/818	13.0		199/1332	14.9		251/1483	16.9	
Richer	101/882	11.5		122/839	14.5		169/1438	11.8		217/1515	14.3	
Richest	120/1224	9.8		125/1295	9.7		184/1854	9.9		189/1734	10.9	
Working status												
Unemployed	325/3217	10.1	0.706	333/2917	11.4	0.41	779/6057	12.9	0.432	688/4664	14.8	0.522
Employed	124/1230	10.1		190/1558	12.2		129/1090	11.8		436/2856	15.3	
Women empowerment												
Not empowered							297/2538	11.7	0.127	356/2712	13.1	0.022[a]
Empowered							541/4103	13.2		648/4271	15.2	
BMI												
Underweight	143/1323	10.8	0.635	165/1127	14.6	0.003[a]	200/1375	14.5	0.023[a]	191/1097	17.4	0.014[a]
Normal	232/2442	9.5		275/2486	11.1		523/4039	12.9		637/4094	15.6	
Overweight	54/513	10.5		59/657	9.0		127/1267	10.0		236/1810	13.0	
Obese	12/116	10.3		24/205	11.7		58/466	12.4		55/461	11.9	
Use of contraception												
Never used	110/708	15.5	< 0.001[a]	155/739	21.0	< 0.001[a]	236/1105	21.4	< 0.001[a]	324/1185	27.3	< 0.001[a]
Ever used	339/3740	9.1		368/3736	9.9		672/6042	11.1		800/6337	12.6	
Age group at first birth												
Adolescent	342/3242	10.5	0.076	398/3117	12.8	< 0.001[a]	720/4973	14.5	< 0.001[a]	902/5358	16.8	< 0.001[a]
Adult	92/1078	8.5		111/1243	8.9		174/2006	8.7		200/2022	9.9	
Number of children ever born												

[a] *Statistically significant*

Variables	2004			2007			2011			2014		
	n/N	%	p-value	n/N	%	p-value	n/N	%	p-value	n/N	%	p-value
0	15/128	11.7	0.003[a]	14/115	12.2	0.016[a]	14/168	8.3	< 0.001[a]	22/142	15.5	< 0.001[a]
1 to 2	69/971	7.1		113/1193	9.5		224/2182	10.3		337/2612	12.9	
3 to 4	184/1801	10.2		214/1827	11.7		412/3237	12.7		510/3362	15.2	
More than 4	181/1548	11.7		182/1340	13.6		258/1560	16.5		255/1406	18.1	
Age at last birth												
≤ 19	19/235	8.1	0.265	33/246	13.4	0.554	77/421	18.3	0.002[a]	112/568	19.7	< 0.001[a]
20–30	291/2771	10.5		332/2816	11.8		614/4748	12.9		804/5147	15.6	
> 30	124/1314	9.4		144/1298	11.1		203/1810	11.2		186/1665	11.2	

[a] *Statistically significant*

Table 2 presents adjusted odds ratios (AORs) from multivariable logistic regression models for PM and EM across survey rounds. After adjustment for covariates, age at first birth, education, contraception use, and number of children emerged as the most consistent associated factors over time. Women whose first birth occurred at age 20 years or older had lower odds of PM or EM compared with those with adolescent first birth. While this association was weak and not statistically significant in earlier surveys, it strengthened in later years. By 2022, adult first birth was associated with 40% less likely to develop PM or EM (AOR 0.60; 95% CI: 0.45–0.81). Women who had ever used contraception had significantly lower odds of PM or EM than never-users, and the magnitude of this association increased over time (AOR in 2004: 0.49; in 2022: 0.28). Women with more than four children had significantly higher odds compared with those with one to two children in several survey rounds, although this association attenuated in later years. Compared with women with no education, those with secondary and higher education had substantially lower odds of PM or EM from 2007 onward. In 2022, higher-educated women had approximately 80% lower odds of PM or EM than women with no education. Place of residence, wealth index, employment status, women's empowerment, body mass index, and age at last birth were not consistently associated with PM or EM after adjustment. Overall, the prevalence of PM and EM declined after 2014; however, associations with educational attainment, age at first birth, and contraceptive use remained consistent across survey rounds.

Table 2
Estimated adjusted odds ratio (AOR) for multivariate logistic regression models of PM or EM

Variables	2004		2007		2011		2014		2017-18		2022	
	AOR (95% CI)	p-value	AOR (95% CI)	p-value	AOR (95% CI)	p-value	AOR (95% CI)	p-value	AOR (95% CI)	p-value	AOR (95% CI)	p-value
Residence												
Urban	ref		ref		ref		ref		ref		ref	
Rural	0.95 (0.71, 1.27)	0.724	0.71 (0.55, 0.91)	0.007[a]	0.91 (0.72, 1.14)	0.411	1.00 (0.79, 1.27)	0.985	1.11 (0.92, 1.34)	0.266	1.05 (0.79, 1.38)	0.753
Level of Education												
No education	ref		ref		ref		ref		ref		ref	
Primary	0.71 (0.55, 0.92)	0.009[a]	0.98 (0.78, 1.23)	0.864	0.95 (0.77, 1.16)	0.584	0.79 (0.61, 1.02)	0.069	0.75 (0.63, 0.89)	0.001[a]	0.64 (0.48, 0.86)	0.003[a]
Secondary	0.93 (0.64, 1.35)	0.705	0.71 (0.52, 0.98)	0.038a	0.70 (0.55, 0.91)	0.008[a]	0.49 (0.37, 0.66)	< 0.001[a]	0.41 (0.33, 0.51)	< 0.001[a]	0.36 (0.26, 0.50)	< 0.001[a]
Higher	1.07 (0.60, 1.91)	0.825	0.34 (0.16, 0.75)	0.008a	0.22 (0.12, 0.43)	< 0.001[a]	0.23 (0.13, 0.42)	< 0.001[a]	0.24 (0.16, 0.36)	< 0.001[a]	0.19 (0.10, 0.36)	< 0.001[a]
Wealth Index												
Poorest	ref		ref		ref		ref		ref		ref	
Poorer	1.15 (0.76, 1.73)	0.513	1.25 (0.85, 1.86)	0.261	1.08 (0.83, 1.41)	0.563	1.42 (1.11, 1.82)	0.006[a]	1.48 (1.18, 1.85)	0.001[a]	1.51 (1.08, 2.11)	0.017[a]
Middle	1.62 (1.09, 2.39)	0.016[a]	1.40 (0.97, 2.04)	0.076	1.30 (0.98, 1.73)	0.069	1.34 (1.03, 1.76)	0.032[a]	1.49 (1.17, 1.89)	0.001[a]	1.42 (0.99, 2.05)	0.059
Richer	1.57 (1.06, 2.34)	0.025[a]	1.72 (1.23, 2.42)	0.002[a]	0.99 (0.73, 1.34)	0.943	1.19 (0.87, 1.63)	0.274	1.13 (0.86, 1.47)	0.376	1.26 (0.87, 1.81)	0.221
Richest	1.48 (0.94, 2.33)	0.087	1.09 (0.74, 1.59)	0.664	1.15 (0.80, 1.66)	0.451	1.15 (0.81, 1.64)	0.428	1.39 (1.04, 1.88)	0.029[a]	1.50 (0.98, 2.32)	0.065
Working Status												
Unemployed	ref		ref		ref		ref		ref		ref	
Employed	0.93 (0.72, 1.19)	0.541	1.03 (0.80, 1.33)	0.828	1.01 (0.76, 1.35)	0.919	1.03 (0.88, 1.22)	0.685	1.22 (1.05, 1.42)	0.008[a]	1.10 (0.88, 1.38)	0.409
Women empowerment												
Not empowered					ref		ref		ref		ref	
Empowered					0.96 (0.80, 1.15)	0.656	1.12 (0.93, 1.35)	0.223	1.03 (0.89, 1.19)	0.73	0.94 (0.76, 1.17)	0.586
BMI												
Underweight	ref		ref		ref		ref		ref		ref	
Normal	0.96 (0.74, 1.24)	0.74	0.85 (0.68, 1.07)	0.17	1.00 (0.79, 1.26)	0.985	1.02 (0.78, 1.33)	0.9	0.86 (0.67, 1.11)	0.243	1.18 (0.78, 1.77)	0.428
Overweight	1.23 (0.78, 1.92)	0.371	0.94 (0.64, 1.39)	0.773	0.90 (0.65, 1.25)	0.522	1.06 (0.78, 1.43)	0.711	0.85 (0.65, 1.11)	0.241	1.22 (0.78, 1.89)	0.378

[a] *Statistically significant*

Variables	2004		2007		2011		2014		2017-18		2022	
	AOR (95% CI)	p-value	AOR (95% CI)	p-value	AOR (95% CI)	p-value	AOR (95% CI)	p-value	AOR (95% CI)	p-value	AOR (95% CI)	p-value
Residence												
Obese	0.92 (0.43, 1.93)	0.818	0.92 (0.51, 1.68)	0.784	1.13 (0.75, 1.71)	0.561	0.86 (0.56, 1.31)	0.48	0.92 (0.66, 1.28)	0.604	0.80 (0.44, 1.43)	0.446
Use of contraception												
Never used	ref		ref		ref		ref		ref		ref	
Ever used	0.49 (0.37, 0.65)	< 0.001[a]	0.39 (0.30, 0.51)	< 0.001[a]	0.33 (0.26, 0.42)	< 0.001[a]	0.31 (0.24, 0.39)	< 0.001[a]	0.30 (0.23, 0.40)	< 0.001[a]	0.28 (0.21, 0.38)	< 0.001[a]
Age group at first birth												
Adolescent	ref		ref		ref		ref		ref		ref	
Adult	0.97 (0.69, 1.35)	0.848	0.80 (0.60, 1.07)	0.127	0.75 (0.60, 0.95)	0.019[a]	0.65 (0.51, 0.81)	< 0.001[a]	0.76 (0.62, 0.93)	0.008[a]	0.60 (0.45, 0.81)	0.001[a]
Number of children ever born												
1 to 2	ref		ref		ref		ref		ref		ref	
3 to 4	1.81 (1.24, 2.64)	0.002[a]	1.10 (0.81, 1.49)	0.557	1.17 (0.91, 1.49)	0.218	1.01 (0.82, 1.25)	0.938	1.03 (0.85, 1.26)	0.745	0.99 (0.77, 1.29)	0.96
More than 4	2.35 (1.50, 3.70)	< 0.001[a]	1.35 (0.90, 2.01)	0.145	1.53 (1.14, 2.06)	0.005[a]	1.26 (0.91, 1.75)	0.169	1.35 (1.05, 1.75)	0.021[a]	1.08 (0.68, 1.71)	0.750
Age at last birth												
≤ 19	ref		ref		ref		ref		ref		ref	
20–30	1.02 (0.54, 1.95)	0.944	1.22 (0.73, 2.04)	0.452	0.70 (0.49, 1.02)	0.064	0.89 (0.61, 1.29)	0.534	0.98 (0.73, 1.30)	0.862	0.96 (0.62, 1.50)	0.871
> 30	0.82 (0.41, 1.65)	0.574	1.00 (0.55, 1.84)	0.991	0.52 (0.34, 0.78)	0.002[a]	0.48 (0.30, 0.78)	0.003[a]	0.72 (0.51, 1.01)	0.058	0.73 (0.42, 1.25)	0.249

[a] *Statistically significant*

Discussion

This study provides the first nationally representative assessment of trends and associated factors of premature menopause (PM) and early menopause (EM) among Bangladeshi women aged 30–44 years. Three key findings emerge. First, PM and EM prevalence increased between 2004 and 2014, followed by a moderate decline through 2022, although levels remain substantial. Second, education, age at first birth, and contraceptive use were the most consistent associated factors across survey rounds, while number of children and wealth index showed weaker or inconsistent associations after adjustment. Third, the strength of association for adolescent first birth and low education increased over time, suggesting that social and reproductive disadvantage is becoming an increasingly powerful predictor of early reproductive aging.

The rise in PM and EM up to mid-2010s, followed by a decline, presents a nuanced pattern. Later onset of menopause being more common in economically developed and urbanized settings, while earlier menopause is more frequently observed in South Asian contexts, particularly among rural or lower-income populations (29). Cross-national analyses from LMICs document secular heterogeneous trends, with several South Asian contexts reporting relatively high or rising prevalence (6, 7). In contrast, recent evidence from India suggests modest declines (from 20.2% to 16.2%) in early menopause (9), which parallels the post-2014 reduction observed here. Several contextual factors may explain Bangladesh's inflection after 2014. The period coincides with intensified maternal and child health investments (2009–2014), National Nutrition Policy (2015) and expanded community health worker programs, which may have disproportionately benefited cohorts reaching reproductive age post-2010 (12, 18). Improvements in adolescent education, delayed marriage, and reduced high-risk fertility behaviors may have lowered cumulative reproductive stressors, which are biologically linked to ovarian reserve depletion. The "accelerated follicular depletion" hypothesis (29) proposes that chronic physiological stress may hastens ovarian aging (30); therefore, better nutritional and reproductive environments may plausibly delay menopause at the population level. However, the continued substantial prevalence of EM indicates that burden remains

influential. The consistently higher prevalence of EM relative to PM is expected given the older age window (40–44 years) and cumulative exposure effects. Biologically, PM represents more abrupt or accelerated follicular depletion, whereas EM may reflect a gradual trajectory of ovarian aging (30). The parallel movement of both trends suggests shared drivers.

Adolescent first birth emerged as a strong and increasingly important determinant. This aligns with evidence from India and other LMICs linking early childbearing to earlier reproductive aging (9, 31, 32). Biologically, adolescent pregnancy occurs during ongoing somatic growth, creating metabolic competition between maternal development and fetal demands (33). Nutritional stress during this critical window may accelerate primordial follicle activation and burnout, reducing reserve faster than normal aging (28, 32, 34–38). The Dutch famine study demonstrated earlier menopause among women exposed to caloric restriction (35), supporting the role of energy balance in ovarian aging. Our findings are concordant with the "critical developmental window" hypothesis, whereby physical burden during adolescence, when the hypothalamic-pituitary-ovarian axis is maturing, may have disproportionate long-term effects (33). The strengthening association over time may reflect compositional shifts. As national rates of adolescent fertility decline, those who continue early childbearing increasingly represent women facing entrenched social and reproductive disadvantage. Early pregnancy in such contexts is often accompanied by undernutrition, limited healthcare access, and shorter birth intervals (39, 40), intensifying cumulative biological strain. Thus, adolescent first birth functions both as a biological exposure and as a marker of social vulnerability.

Number of children showed a more nuanced pattern. Higher number of children was associated with elevated odds of PM/EM in earlier survey rounds, but this relationship weakened in later years. Studies from South Asia similarly link high parity with earlier menopause (9, 31), plausibly through micronutrient depletion and oxidative stress (34, 39). In contrast, some high-income settings report neutral or protective associations (2), possibly due to better nutritional buffering and better healthcare access. The divergence underscores contextual differences: in LMIC settings characterized by undernutrition, high parity may reflect cumulative biological strain rather than hormonal suppression benefits. The attenuation of parity effects in later BDHS rounds may signal improvements in maternal nutrition and spacing practices, reducing physiological stress per pregnancy (19–24). This suggests that contextual conditions modulate how reproductive exposures translate into ovarian aging.

Ever use of contraception was consistently associated with lower odds of PM/EM. Hormonal methods suppress ovulation and may temporarily suppress ovulation, although evidence that hormonal contraception delays natural menopause remains inconsistent (41, 42). However, a systematic reviews also note that prolonged hormonal contraception can transiently suppress ovarian reserve markers without necessarily altering ultimate menopause timing (43). Thus, the biological effect remains debated. Behavioral pathways likely contribute: contraceptive users tend to delay first birth, limit parity, and engage more with health services - factors independently associated with later menopause. In Bangladesh, expanded access to modern contraception and greater reproductive autonomy may therefore operate through both physiological and socioeconomic mechanisms. Underweight women exhibited higher prevalence of PM/EM, consistent with literature linking low BMI and undernutrition to earlier menopause (2, 28). However, adjusted associations were inconsistent, possibly due to cross-sectional measurement of BMI, which may not capture lifetime nutritional exposure. Early-life deprivation and adolescent undernutrition may be more relevant to ovarian aging than adult weight status alone. Other reproductive variables may also statistically buffer the effect of nutritional status. Education emerged as the most consistent and increasingly protective determinant across all survey rounds. Women with secondary or higher education had markedly lower odds of PM/EM, consistent with evidence from India, Iran, and multi-country analyses (2, 9, 32, 44). Education influences reproductive aging through delayed marriage and first birth, reduced high parity, improved nutrition, and greater healthcare utilization. In Bangladesh, expansion of female education has been closely linked to fertility decline and improved maternal health indicators (12, 28, 35).

These findings reveal a dual narrative. On one hand, national investments in education, nutrition, and family planning appear to have positively shifted reproductive aging trajectories at the population level. On the other, persistent and intensifying associations with adolescent first birth and low education underscore enduring disparities. Given established links between early menopause and cardiovascular disease, osteoporosis, and other morbidity (3, 4), these disparities may translate into unequal burdens of non-communicable diseases later in life.

Policy implications extend beyond fertility control to encompass long-term women's health and healthy aging. Strategies such as delaying adolescent marriage and first birth, promoting girls' secondary education, improving adolescent nutrition, and ensuring equitable access to contraception can shape reproductive trajectories and reduce early health risks. Early and premature menopause linked to cardiovascular disease, osteoporosis, metabolic disorders, and cognitive decline which appears relatively prevalent in Bangladesh, indicating that many women may enter high-risk periods earlier than expected. Integrating menopause awareness, risk assessment, and screening into reproductive and primary healthcare services could enable early identification of vulnerable groups, particularly women with histories of adolescent childbirth or low education. While recent declines in premature menopause are encouraging, persistent inequalities highlight the need for equity-focused, life-course approaches to translate reproductive health gains into healthier aging outcomes for all women.

The strengths of this study include using six nationally representative BDHS rounds spanning two decades, ensuring robust trend analysis. Standardized data collection and large sample sizes enhance comparability and precision. However, reliance on self-reported amenorrhea may introduce recall bias. The cross-sectional design precludes causal inference, and unmeasured factors such as age at menarche, smoking, environmental exposures, and genetic predisposition were unavailable. A proxy measure of menopause based on the DHS definition, which differs from the international clinical definition requiring 12 months of amenorrhea. Additionally, clinical causes of menopause (e.g., autoimmune or iatrogenic factors) could not be distinguished. Women with surgically induced menopause could not be distinguished from those experiencing natural menopause. Because information on the indication, timing, or type of hysterectomy (with or without bilateral oophorectomy) is not collected in the BDHS. Although hysterectomy prevalence is generally low among Bangladeshi women of reproductive age, this may have resulted in some misclassification of natural menopause and a modest overestimation of the prevalence of premature or early menopause, particularly among women who underwent gynecological surgery before the natural age of menopause.

Conclusions

In summary, premature and early menopause in Bangladesh followed a rise-and-decline trajectory over the past two decades, affecting nearly one in ten Bangladeshi women, which is a public health concern that responsive to policy investment. The observed decline from 2014 onward, coinciding with Bangladesh's intensified maternal health programs, provides insights that reproductive aging can be delayed through interventions targeting education, family planning, and reducing adolescent marriage also. Therefore, the path forward is to initiate and scale proven interventions to reach the last mile.

Abbreviations

PM
Premature menopause
EM
Early menopause
BDHS
Bangladesh Demographic and Health Survey
LMICs
low- and middle-income countries

Declarations

Ethics approval and consent to participate:

This study used secondary data from the six rounds of the Bangladesh Demographic and Health Survey (BDHS) that took place between 2004 and 2022. The BDHS surveys were conducted with informed consent of participants and in accordance with the relevant ethical and regulatory guidelines. The present study analyzed de-identified secondary data that was accessed via the Demographic and Health Surveys (DHS) Program data-access process.

Consent for publication:

Not applicable.

Competing interests:

The authors declare that they have no competing interests.

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Author Contribution

Conceptualization: SM; Data analysis: SM, RBI and AH; Methodology: SM, AS, and STAN. Supervision: AS and AA; Writing– original draft: SM; writing– review and editing: RBI, STAN, MRUZS, LH, STE, AK, FR, SZAN, and AS. Authors have read and agreed to the published version of the manuscript. AS and AA are co-senior authors and contributed equally to this work

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Data Availability

The data analyzed and used in the current study is available from the DHS Program. The BDHS dataset(s) are available under the terms and conditions of the DHS Program data-access and use conditions. The datasets are available for researchers to request access to, as per the DHS Program data-access procedure.

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Figures

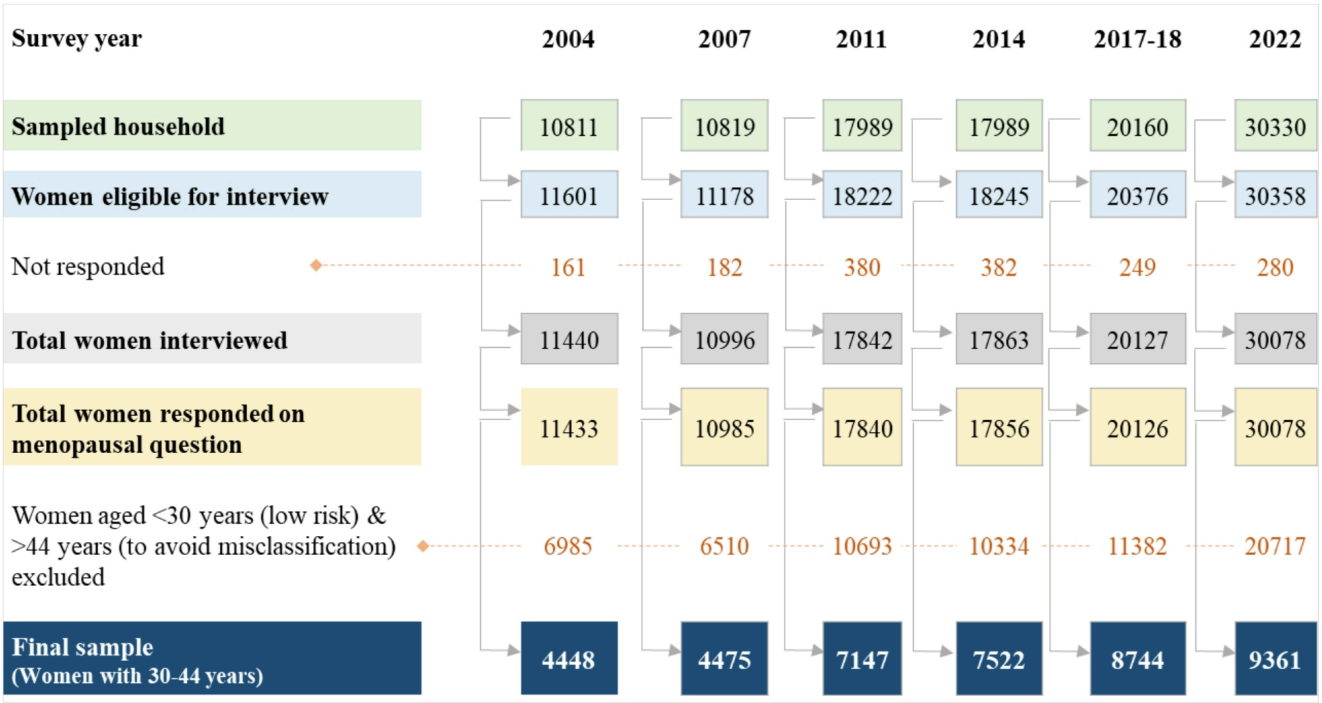

Figure 1

Study population selection process

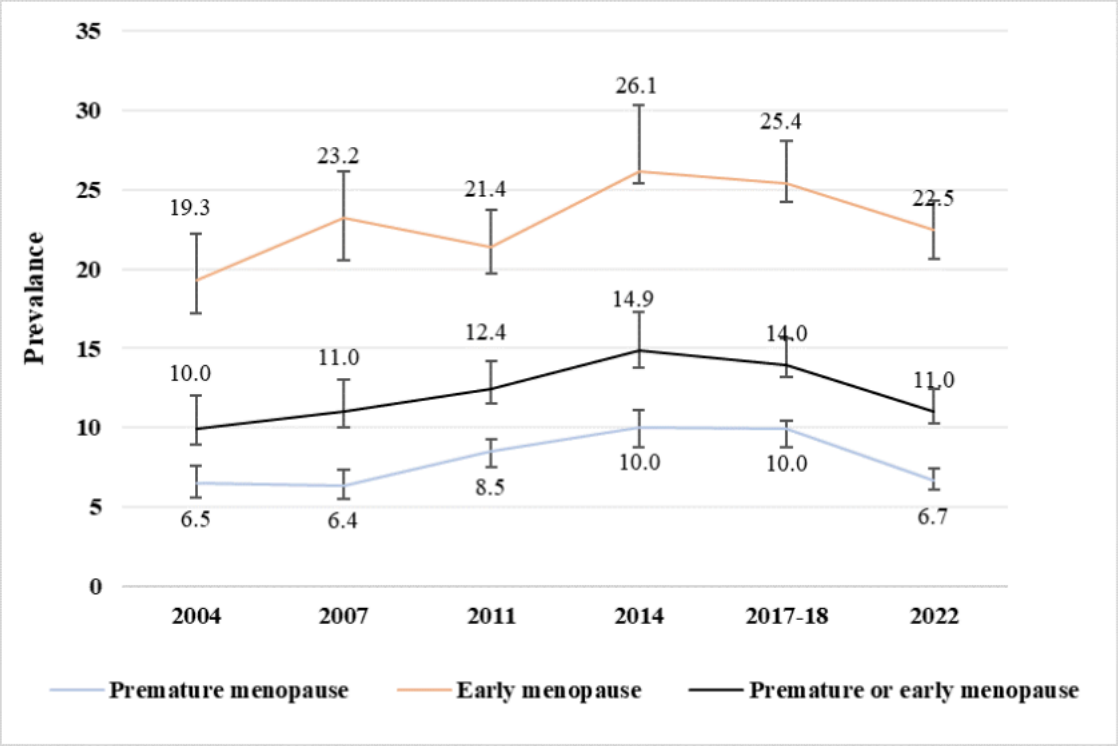

Figure 2

Trends of EM and PM in Bangladesh among 30-44 year's old women from 2004 to 2022

Supplementary Files

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