
| RESEARCH ARTICLE

The Impact of High C-Section Rates on Bangladesh's Progress Towards SDG 3.1

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| ABSTRACT

Bangladesh has substantially reduced maternal mortality amid rapid growth in C-section use, yet Sustainable Development Goal (SDG) 3.1 remains unmet. The objective of this ecological secondary data analysis was to explore national co-trends, district inequalities, and the consequences for meeting the aim of fewer than 70 maternal deaths per 100,000 live births by 2030. The data covered the seven rounds of the Bangladesh Demographic and Health Surveys (1999/2000-2022) as well as annual estimates of maternal mortality ratio (MMR) at WHO/United Nations level (2000-2023) and survey-weighted estimates of C-section rates for all 64 districts in 2022. Analyses included average annual reduction rates, 2030 continuation scenarios, district variation and uncertainty, and matched-year correlation. National C-section use rose from 2.8% to 44.0% and facility delivery from 8.7% to 63.5%, while MMR declined from 522.7 to 115.1. The long-term trend 2030 MMR was 72.6 and the recent trend 2030 MMR was 69.9. District estimates of the C-section ranged from 10.0% to 77.0% of the total population, with 48 districts having estimates higher than 30%, 26 higher than 50%, and five higher than 70% of the total, with 25 districts having reliability limitations. The association between the use of cesarean section and MMR was strongly negatively correlation ($r = -0.922$), but the opposite temporal trends do not allow for causal inferences. Satisfactory provision of C-sections, improved essential obstetric services, district responsive interventions, and condition-specific monitoring are all critical for achieving SDG 3.1.

| KEYWORDS

Bangladesh; Cesarean section; Maternal mortality; Sustainable Development Goal 3.1; Health inequality.

| ARTICLE INFORMATION

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1. Introduction

Maternal mortality is a significant public-health problem worldwide, as deaths occur in pregnancy, childbirth and the immediate postpartum period, in locations where timely and appropriate health care is not readily available. SDG Target 3.1 aims to reduce the international maternal mortality ratio (MMR) to less than 70 per 100,000 live births by 2030. The skilled attendance at birth, effective referral, blood and anaesthesia capacity, emergency obstetric care, and prompt treatment of haemorrhage, sepsis and hypertension are necessary for achieving achievement. Though Bangladesh has made significant reduction in MMR in the long term, socioeconomic inequality, nonuniform facility readiness, and the gap with the SDG pose risks of failure to meet the goal. As the number of institutional births has grown and the rates of cesarean section (C-section) have risen rapidly over the years, this concern has gained momentum (Raina et al., 2023; Souza et al., 2024).

C-section is an important, life-saving procedure where vaginal delivery would pose a risk to the woman or fetus. Obstructed labour, placenta previa, malpresentation, threatened uterine rupture and in selected cases, fetal compromise are clinical indications. However, surgery for a clinically indicated indication must be separated from when surgery is used for an indication that is not clinically demonstrated. A high population rate cannot detect inappropriate procedures because household surveys do not include clinical indication, previous cesarian, referral severity or case-mix. Widespread data from around the world shows an increase in cesarean sections, especially in the South Asian and other middle-income countries. While this is partly due to better access to key surgery, this may also be due to increased rates of procedures at the facility level that are provided beyond clinical need. Appropriateness, safety, distribution, and opportunity costs from the health system must, therefore, be taken into account in the evaluation, not to be confused with the notion that more coverage equals better outcomes (Angolile et al., 2023; Betrán et al., 2018).

Using C-section can be beneficial and detrimental to the health of the mother. Undelayed surgery can avert the death and debilitating consequences of obstructed labour, uterine rupture and antepartum haemorrhage. On the other hand, surgical delivery can present risks of haemorrhage, infection, complications related to anaesthetic, thromboembolism, injury to organs, and a long recovery period, as well as complications in subsequent pregnancies such as placenta accreta spectrum, and uterine rupture. These risks are dependent on clinical indication, baseline obstetric risk, surgical quality, availability of blood and antibiotics and postoperative monitoring. Another nuance is that women who have severe complications are more likely to have surgery, which makes it difficult to interpret because of confounding by indication. The C-section prevalence of the aggregate cannot, therefore, prove a direct impact on maternal mortality, but can only be used to determine whether there is the possibility of unnecessary use or a diversion of resources in the absence of clinical and health-system data showing a direct impact (Keag et al., 2018; Mascarello et al., 2017; Sobhy et al., 2019).

Bangladesh is an important transitional setting as its use of institutions and C-sections have risen very rapidly, although unevenly. National studies link C-section delivery with being from urban areas, having higher levels of household wealth, higher education, lower parity, advanced maternal age, higher attendance at antenatal care and use of private facilities. Recent surveys of practices have raised concerns about provider recommendation, scheduling, maternal preference and financial incentives as these are concentrated in private facilities, but these surveys do not allow for determination of the necessity of individual procedures. National averages also mask significant variation within the district. Such patterns result in a double burden, as socioeconomically privileged women can be subjected to interventions, which are not clinically indicated, whilst poor, rural and geographically remote women may miss timely emergency surgery. A uniformity of reduction may limit access to essentials, while uncontrolled expansion may lead to an increase in procedural damage and divert resources from the referral, blood supply, infection control and post-partum monitoring (Ahmmed et al., 2021; Khan et al., 2022, 2023).

The major evidence gap is that there is a limited integration of C-section growth, progress in inequality and maternal-mortality in a national SDG framework. Prevalence, socioeconomic determinants, spatial clustering or reported indications have been studied in previous Bangladesh studies, though most of these have concentrated on one survey round or locality. This evidence provides only the identity of the child being delivered by C-section and does not always correlate long-term intervention patterns with the SDG 3.1 trajectory, or make comparative assessments of district estimates and their statistical reliability. Other factors such as clinical indication, prior cesarean section, referral severity and facility ownership and readiness are underrepresented. Geographic evidence at the district level has been strengthened by recent evidence, and population-based evidence from Matlab clarifies local indications and decision-making factors. However, neither concludes whether an increase in C-section delivery is an impediment or a catalyst to reduction in maternal deaths. A national assessment, therefore, requires differentiation between descriptive co-trend and causal effect and a need to interpret geographic variation in the context of overuse and underuse (Begum et al., 2017; Khan et al., 2025).

Thus, national trends are measured based on Bangladesh Demographic and Health Survey and WHO/United Nations estimates, and geographic inequality is measured based on survey weighted estimates of 2022 for all 64

districts. The analysis avoids equating high aggregate prevalence with individually unnecessary surgery or direct causal impact. The study addresses two research questions:

1. What was the national trend in the use of C-section delivery, facility delivery and maternal mortality and what is the difference from the SDG 3.1 target by 2030?
2. How did district-level C-section rates and their reliability vary across Bangladesh in 2022?

Thus, the study aims to achieve two objectives:

1. To measure national trends and Bangladesh's progress and continuation scenarios with regard to SDG 3.1.
2. To describe the variation in C-section rates, inequality and reliability at the district level and provide policy implications.

"The study adopts a balanced health-system interpretation that distinguishes between potential overuse and unmet access without equating high prevalence with unnecessary surgery or a direct causal effect on SDG 3.1.

2. Literature Review

2.1 Global and South Asian Obstetric Transition

The upward trend in C-section is often interpreted as underuse and overuse due to its global prevalence. There has been an overall rise in rates in most parts of the world, but rates are very low in some parts of sub-Saharan Africa and very high in Latin America, Eastern Asia and some middle-income countries. Inequalities within countries can also be as large as inequalities across countries (Boerma et al., 2018). Studies based in South and South-East Asia link urban living, education, wealth, low parity, and the use of private facilities with C-section births, though the association to these different factors varies across health systems (Verma et al., 2020). The findings of the recent regional analysis further support the continued rise of Bangladesh, Nepal and Pakistan; however, no evidence has been found to support similar drivers across countries (Rana et al., 2024). Evidence from the prospective registry also indicates that higher use settings are more likely to have evidence of primary pre-labour procedures, post-induction procedures, and repeat procedures, while very low use settings have evidence of limited access (Harrison et al., 2020). These results would suggest a model of obstetric transition that proposes that more initial expansion of facilities will lead to better access to essential surgery, but will also lead to more facility-based intervention afterwards. But ecological comparisons still are vulnerable to case mix, referral severity and measurement differences. Bangladesh thus needs to tackle the double challenge of under-intervention, and of over-intervention.

2.2 Maternal Consequences, Subsequent Pregnancy and Quality of Care

The consequences of C-section depend on clinical indication, timing and quality of care. The short-term risks include infection, haemorrhage, anaesthetic problems and slow recovery, and the longer-term risks are subfertility, abnormal placentation, and problems in future pregnancies. Despite this, surgery has some advantages in specific clinical situations for selected neonatal and pelvic-floor outcomes (Sandall et al., 2018). The microbiomes studies have revealed potential pathways involving delivery mode and subsequent immune and metabolic development, but there is a lack of mechanistic variation and the possibility of residual confounding, which makes causal interpretation limited (Ríos-Covian et al., 2021). Delayed initiation of breastfeeding has also been found to be linked with C-section delivery, yet emergency indication, separation from the mother after the surgery and institutional practice might account for some of this association (Taha et al., 2019). The choice of repeat caesarean section versus TOL is not equally risky for mothers and babies with a prior cesarean section, and facility capacity and patient suitability are more important than a preference for a single mode of delivery (Kietpeerakool et al., 2019). Based on the evidence, it is not possible to conclude that c-section is anywhere beneficial or detrimental. The factors likely to impact outcomes in Bangladesh include delay in referral, infection control, availability of blood, anaesthetic and monitoring of the postoperative period. The burden cannot only be captured by MMR, but also by monitoring severe maternal morbidity, near miss and readmission too.

2.3 Socioeconomic, Geographic and Obstetric Inequalities in Bangladesh

The sociodemographic gradient of C-section rates is consistently seen across the data from Bangladesh, but the power of each of the individual effect modifiers ranges across the different studies and model specifications used. BDHS 2014 found that maternal education, household wealth, urban residence, antenatal care, and facility delivery were significantly associated with increased C-section rates, though the association was not fully explained after controlling for obstetric indication and provider selection (Rahman et al., 2018). The socioeconomic and demographic risk factors for both elective and emergency procedures were found to be overlapping, however, retrospective classification was not a suitable alternative to the clinical records established by BDHS 2017–18 (Muhammad et al., 2022). An urban-rural analysis reveals that residence is associated with different access conditions, and that the determinants of wealth, education, parity, reported size and antenatal contacts are different as well, suggesting that residence is a measure of both access conditions and of maternity-market structure (Abdulla et al., 2023). Overall, this evidence indicates that C-section use increased over the past 17 years, and despite this increase, there has been a continued geographic and socioeconomic disparity among women, with high rates among women who were more highly educated and less among those who were less (Kundu et al., 2024). These findings put together create a very strong rich-poor and urban-rural gradient, but do not demonstrate that grassroots use is not needed among the most disadvantaged women nor that the higher use among the most advantaged women is unmet need. Clinical indication, previous cesarean section, pregnancy risk, referrals and facility capability are all factors that contribute to reliable interpretation.

2.4 Provider, Community and Market Drivers

Decisions for C-section are made in the process of interactions between women, families, providers and institutions. The results of the national evidence suggest that, individual socioeconomic factors, community norms do also shape the choice of delivery, possibly due to shared perceptions of modernity, convenience and safety (Haque et al., 2025). In the hospital-based research conducted by Jashore, clinical and demographic correlates are identified, but no separation of referral severity and provider practice is possible since the women being observed are selected in the hospital (Hossain et al., 2024). The inequality decomposition of BDHS 2017–18 shows that the concentration of wealth among households is a significant contributor to the overall inequality, and private-sector access and market organization are placed at the heart of the national pattern (Kumar & Sharma, 2023). International findings also show a higher risk of cesarean section in for-profit compared to non-profit hospitals, but these findings are heterogeneous and most studies come from developed countries, which cannot be directly applied to Bangladesh (Hoxha et al., 2017). Financial incentives, as a result, are possible but not substantiated. Other potential factors are maternal preference, fear of labour, timing issues, provider risk perception, and defensive practice, as well as having limited alternatives for safe labour management. To improve the strength of inference, direct measures of facility ownership, preparedness, staffing, case mix, referral status, price, and decision timing should be employed.

2.5 Intervention Evidence, Research Gap and Conceptual Positioning

Interventions to reduce C-section use must remain selective and safety-oriented. Childbirth education, clinical guidelines, required second opinions and audit are identified as potentially effective, with varying levels of certainty, and medically indicated procedures must be protected (Betrán et al., 2018). Audit and feedback, which has been shown to reduce implementation, has been more effective as a monitoring tool than as a guaranteed intervention, due to uncontrolled designs and the high risk of bias (Boatin et al., 2018). Evidence shows that the risks and benefits of C-section have evolved over time as the practice of using antibiotics, anesthesia, transfusion, and surgical technique has improved, highlighting the need to look at the context. The costs of procedures, complications, and patient experience and follow-up should also be assessed together, rather than assessing procedure rates alone.

The principal gap in Bangladesh is the limited integration of national C-section trends, SDG 3.1 progress, district inequality, estimate reliability and public–private pathways within one analytical framework. The present study positions C-section use within a double-burden pathway: appropriate emergency access may support mortality reduction, whereas use beyond demonstrated need may increase avoidable morbidity and divert health-system capacity.

3. Methodology

3.1 Study design

Ecological repeated cross-sectional study design was adopted to study the change in C-section use and maternal mortality in Bangladesh. The analysis comprised two complementary components. The national component included an evaluation of the trend of C-section use, facility delivery and maternal mortality ratio (MMR), as well as Bangladesh's progress towards Sustainable Development Goal (SDG) Target 3.1. The district component analyzed geographic variation and the reliability of the estimates of c-section deliveries for all 64 districts in 2022. National and district estimates were considered separately as they were different time periods and different unit of analysis.

3.2 Study setting and periods

The study was conducted at national and district level of Bangladesh. The national obstetric-service analysis covered the seven rounds of Bangladesh Demographic and Health Survey (BDHS) that were conducted in 1999/00, 2004, 2007, 2011, 2014, 2017–18 and 2022. Annual national estimates of MMR for the time frame from 2000 to 2023. For district-level analysis, all 64 districts were analyzed and the analysis was limited to 2022, the only year in which district estimates of the C-section were available.

BDHS indicators were presented for each survey round, while MMR estimates were presented annually. The 7 periods of the BDHS survey and the annual estimates for MMR were used in the analyses involving both measures. District estimates were a one-time snapshot and not used to track district-level change over time.

3.3 Data sources

The national and district estimates of C-section were derived from the analysis of BDHS data reported by Khan et al., 2025. National data were provided for facility delivery rates, overall and institutional rates of cesarean section, and their 95% confidence intervals. A survey-weighted C-section point estimate, 95% confidence interval, sample size, and reliability classification were available for the district dataset for all 64 districts in 2022.

The annual MMR estimates are from the World Health Organization (WHO) and the United Nations Maternal Mortality Estimation Inter-Agency Group (UN MMEIG). MMR was reported as the number of deaths per 100,000 live births. WHO/UN MMEIG reported lower and upper bounds of uncertainty as the 10th and 90th percentiles, respectively, and were thus considered 80th percentile uncertainty intervals.

The Bangladesh Maternal Mortality and Health Care Survey 2001, 2010 and 2016 estimates were used to assess the consistency in direction and magnitude of the change in maternal mortality. BMMS estimates were not numerically merged with the estimates from the WHO/UN MMEIG due to the differences in source definition and estimation methods as well as different reference periods.

Table 1: Data sources, coverage and analytical roles

Data source	Coverage	Measures used	Analytical role
BDHS-derived national estimates	Seven rounds, 1999/2000-2022	Facility delivery, overall C-section use, institutional C-section use and 95% confidence intervals	National trend and matched-year analyses
BDHS-derived district estimates	All 64 districts, 2022	C-section point estimates, 95% confidence intervals, sample sizes and reliability classifications	District variation, inequality and uncertainty assessment
WHO/UN MMEIG	Annual estimates, 2000-2023	MMR and 80% uncertainty intervals	SDG 3.1 gap, average annual reduction rate and 2030 continuation scenarios
BMMS	2001, 2010 and 2016	Survey-based maternal-mortality estimates	Triangulation of maternal-mortality trends

Note. BDHS = Bangladesh Demographic and Health Survey; BMMS = Bangladesh Maternal Mortality and Health Care Survey; MMR = maternal mortality ratio; MMEIG = Maternal Mortality Estimation Inter-Agency Group.

3.4 Measures

3.4.1 Maternal mortality and SDG 3.1 progress

The national MMR was the principle maternal health indicator. In the main analysis, the median estimate of WHO/UN MMEIG was used and the corresponding 80% uncertainty interval reported as estimation uncertainty. The SDG 3.1 target for reducing maternal deaths to fewer than 70 per 100,000 live births was used to assess progress towards SDG 3.1.

The annual distance from the SDG threshold was calculated as:

$$SDGGap_t = MMR_t - 70 \dots \dots \dots (i)$$

A positive value indicated that the national MMR remained above the SDG 3.1 threshold.

3.4.2 C-section and facility-delivery indicators

The principal obstetric-service indicator was the overall C-section rate, which is the proportion of all births that are delivered by C-section. The facility delivery rate was defined as the proportion of deliveries in a health facility. The institutional C-section rate was the proportion of deliveries that were C-section. These indicators captured the trends in use of maternity services at the population-level. Geographic variation was assessed using district C-section estimates, which were not comprehensive enough to determine the indication or appropriateness of individual C-sections.

3.4.3 District estimate reliability

District reliability was measured and reported in the source dataset. The estimates with less than 25 unweighted observations were regarded as unreliable. Estimates made with 25-49 observations were considered small sample

estimates, and used with caution. The numbers with at least 50 observations were deemed to be relatively more reliable. Additionally, the width of the confidence intervals was explored as these wider intervals represented increased uncertainty about district point estimates.

3.5 Statistical analysis

3.5.1 National trend analysis

For each BDHS round, the national level rates of facility delivery, overall C-section and institutional C-section were summarized. The percentage point change in percentage indicators was reported. MMR change was reported as both an absolute difference in deaths per 100,000 live births and a relative percentage decline.

The average annual reduction rate (AARR) in MMR between an initial year (0) and a subsequent year (t) was calculated as:

$$AARR = 1 - \left(\frac{MMR_t}{MMR_0} \right)^{1/n} \dots\dots\dots(ii)$$

where (n) represented the number of elapsed years.

The AARR required to reduce the 2023 MMR to the SDG threshold by 2030 was calculated as:

$$AARR_{(required)} = 1 - (70/MMR_{2023})^{(1/7)} \dots\dots\dots(iii)$$

Continuation scenarios were calculated using:

$$MMR_{2030} = MMR_{2023}(1 - AARR)^7 \dots\dots\dots(iv)$$

The basic continuation scenario used the long-term AARR of 2000-2023. The more recent AARR (2015–2023) was used for a sensitivity scenario. The two periods were compared to find out if the assessment of SDG attainment differed if the recent rate of reduction of maternal mortality was applied rather than the long-term rate.

Over all the C-section rate was correlated with MMR at seven matched BDHS survey points using Pearson's correlation coefficient. The coefficient was a summary of the nature and intensity of national co-variations between the two indicators. The findings were interpreted with the knowledge that use of both the C-section delivery and MMR vaccine dropped over calendar time.

3.5.2 District-level analysis

Unweighted mean, unweighted median, unweighted sample standard deviation, minimum, maximum, and range were used to summarise the 64 district C-section point estimates. The numbers and percentages of districts with C-section rates of 30% or lower, 30.1–50.0%, 50.1–70.0% and above 70% were calculated. The unweighted district mean was used to describe the distribution of district estimates, but was not considered a population-weighted national C-section rate.

The overall range, interdistrict dispersion, and concentration of districts in the higher categories were measured for district inequality. The districts were ranked by point estimates and their 95% confidence intervals and reliability classifications were considered. When assessing apparent differences between districts, the following factors were taken into account: overlapping confidence intervals; and small sample sizes.

Uncertainty was also summarized by the mean and median widths of the district confidence interval and estimates that were designated as 'small sample' or 'unreliable'. Because all 64 districts had point estimates, no imputation of missing district values were done.

3.5.3 Analytical conventions

Any percentages that were retained were kept between 0-100 scale. Absolute changes in the proportions of C-section and facility delivery were reported in percentage points and not as decimals of a percentage. The uncertainty intervals reported by WHO/UN MMEIG were separated from BDHS confidence intervals due to the differences in their types of uncertainty. The national survey-round estimates, annual MMR estimates and district estimates have been retained at their original analytical level and are not combined into a single estimator.

3.6 Data quality and sensitivity assessment

Data quality checks included checking the seven national survey rounds for completeness, checking all 64 districts, chronologically ordering the surveys, checking measurement scales and the numerical ranges of the validity checks. District reliability classifications were compared to reported sample-size classifications. National C-section and facility-delivery rates were compared across consecutive survey rounds to identify possible transcription or scaling errors.

The long-term and recent-period AARR scenarios were compared in a sensitivity assessment. District summaries were also analyzed with and without the unreliable estimates to assess if the general trend of geographic variation was driven by the presence of very small samples. All calculations were written down in the study analysis workbook and checked independently using Python 3.

3.7 Ethical considerations

Secondary, aggregate estimates were derived from published data sources and national survey outputs. Access of names, personal identifiers or individual participant records was not permitted. No attempt was made to recruit, contact or intervene with the participants. The original survey studies determined the ethical approval and informed-consent procedures that were applicable to the surveys. No additional participant consent was needed to analyse non-identifiable aggregate estimates.

3.8 Analytical considerations

National, annual and district datasets were different in terms of their unit of analysis and time, and therefore analyzed separately. The national analysis evaluated the trends in the population over time and progress towards SDG 3.1, while the district analysis evaluated the distribution and reliability of C-section estimates in 2022. The ecological design did not incorporate individual clinical indications, previous cesarean, pregnancy risk, severity of referral, ownership of the facility, surgical quality, blood availability or cause and timing of maternal death. The findings thus support population-level evaluation of trends in maternal health and geographic inequality and patterns of service use, not individual clinical decisions.

4. Results and Discussion

4.1 National expansion of C-section use and maternal mortality progress

The growth in the facility delivery and C-section rate was significant in Bangladesh. The overall C-section rate rose from 2.8% in BDHS 1999/2000 to 44.0% in BDHS 2022, which is an absolute increase of 41.2 percentage points. The facility-delivery rate saw a 54.8 percentage point increase, from 8.7% to 63.5%, during the same period. In 2022, 69.3% of all births at facilities were by Caesarean section. The indicators are arithmetically consistent because the 63.5% facility-delivery rate, combined with an institutional C-section rate of 69.3%, yields a rate of approximately 44.0%, which is close to the observed rate.

The national maternal mortality ratio (MMR) in the same period of time fell from 522.7 per 100,000 live births in 2000 to 115.1 in 2023, a relative decrease of 78.0% and an absolute decrease of 407.5. The use of c-section and MMR was very strongly negatively correlated across the 7 matched national observations ($r = -0.922$). The overall association is mostly driven by the increase in C-section and reduction in maternal deaths as time passes. Other factors that could have influenced the observed mortality trend include improved skilled birth attendance, emergency obstetric care, referral systems, women's education, fertility patterns, and poverty reduction efforts, as well as better health-system performance.

Table 2: Observed national indicators and progress toward SDG 3.1

Indicator	Start/basis	Latest/result	Change or gap	Interpretation
Overall C-section rate	2.8% (1999/2000)	44.0% (2022)	+41.2 pp	Large expansion in use
Facility-delivery rate	8.7% (1999/2000)	63.5% (2022)	+54.8 pp	Substantial institutionalization of childbirth
WHO/UN MMR	522.7 (2000)	115.1 (2023)	-407.5; -78.0%	Large decline, although the target had not been reached
2023 SDG gap	Target <70	115.1	+45.1	MMR remained above the SDG 3.1 threshold
AARR and 2030 scenarios	6.37% long-run; 6.88% recent	6.86% required; 72.6/69.9	+2.6/-0.1 relative to 70	Target attainment is sensitive to the selected trend period

Sources: BDHS-derived estimates and WHO/UN MMEIG. AARR = average annual reduction rate; MMR = maternal mortality ratio; pp = percentage points. The projection results represent arithmetic continuation scenarios rather than forecasts.

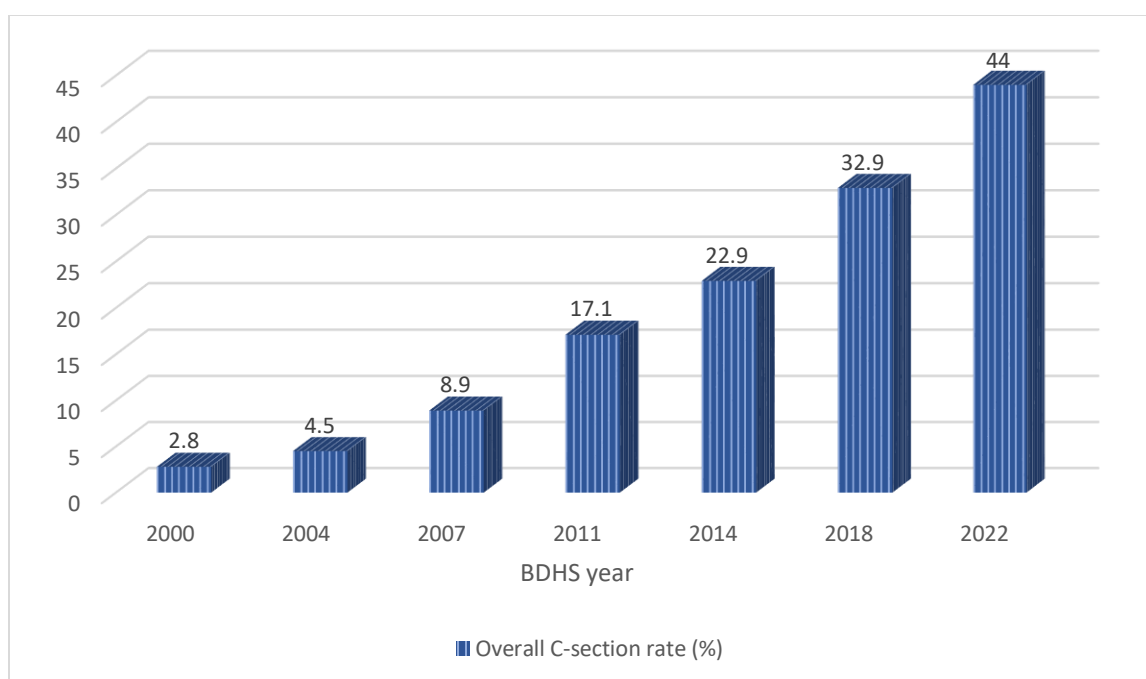


Figure 1: National C-section rate across seven BDHS rounds, 1999/2000-2022

Source: BDHS-derived estimates reproduced by (Khan et al., 2025). Exact values are presented in the accompanying source-data table.

The parallel trend of rising facility delivery along with rising institutional C-section rates suggest that there was a significant shift in mode of birth along with increasing rates of facility delivery. This pattern cannot be understood solely as overuse. At the higher aggregate rates, medically indicated C-sections might be life-saving, but when access is restricted, an additional procedure could be variation in clinical practice, financial incentives, patient preference or limited access to labour management options. There is no distinction in the national series between these mechanisms. Policy should therefore be prioritised to ensure safe and clinically appropriate use whilst not compromising timely access to emergency operative delivery.

The magnitude of the national rise is similar to recent data from Bangladesh, and the overall South Asian obstetric transition. However, the parallel increase in C-section rates and decrease in MMR rates prevents a one-sided

explanation. There is evidence that the same expansion of access to emergency care could also involve focusing the intervention on the socioeconomically privileged (Khan et al., 2022, 2025). The focus of central policy is therefore the suitability, safety and use of C-sections, but not the national rate alone.

4.2 SDG 3.1 trajectory and the 2030 threshold

In 2023, the estimated MMR of 115.1 was still 45.1 deaths per 100,000 live births higher than the SDG 3.1 target. The uncertainty interval, which was 80% of its size, was from 82.2 to 166.6, which was entirely above 70. The AARR for Bangladesh has been 6.37% over the last 23 years (2000-2023), while the target is 6.86% for the next 7 years (2023-2030). A continuation of the long-run rate would set MMR at 72.6 in 2030, about 2.6 points above the target. If the rate of 6.88% is applied to the more recent 2015-2023, then the estimated MMR is 69.9 which is close to the threshold.

These two continuation scenarios illustrate the sensitivity of the attainability estimate to the trend period chosen, and they bracket the SDG target. However, the median estimate for the annual series was not consistent, with a higher estimate in 2021 (193.9) compared to 2020 (151.8) and then falling to 115.1 in 2023. Whatever the reasons behind this interruption are, the pattern shows that a short blip in momentum could have a significant impact on the 2030 plan. In this context, Bangladesh needs to continue cutting by about 6.9% annually, and not just a single year.

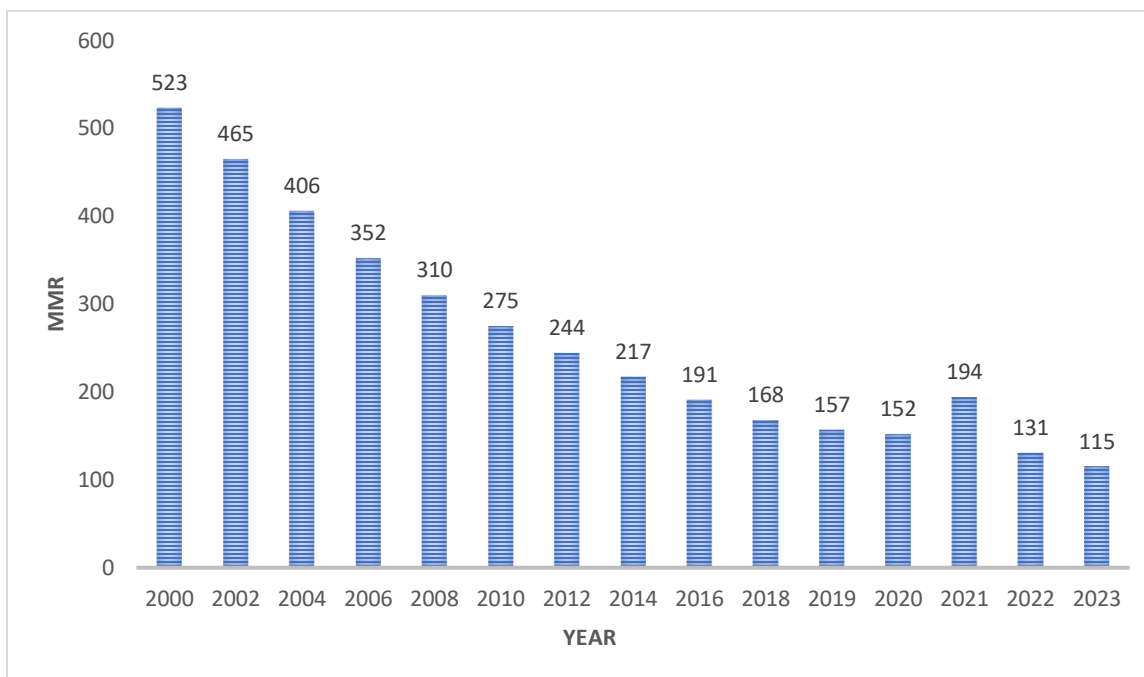


Figure 2: Selected WHO/UN MMEIG maternal mortality ratio estimates and the SDG 3.1 threshold, 2000-2023. Source: WHO/UN MMEIG. MMR is expressed as maternal deaths per 100,000 live births. The SDG 3.1 threshold is fewer than 70 deaths per 100,000 live births. Median estimates are shown, the 80% uncertainty intervals are not displayed.

The trend shows significant improvement but there is very little room for the deviation from the prescribed reduction. Therefore, policies relating to the use of C-section should be considered in light of this larger maternal health goal. Appropriate reduction in non-indicated surgery can result in good safety and resource efficiency but arbitrary numerical reduction could result in a delay in emergency surgery and risk loss of mortality benefits. The monitoring system needs to be able to tell the difference between under and overt intervention, and to track maternal outcomes as well as clinical appropriateness.

4.3 District heterogeneity and estimate reliability

Use of C-section was found to be very unevenly distributed in the 64 districts of BDHS 2022. The unweighted mean of the district estimates was 44.76%, the median was 45.55% and the sample standard deviation was 17.81 percentage points. Ranges were from 10.0% to 77.0% in the respective areas. In total, 48 of 64 districts (75.0%) exceeded 30%, 26 (40.6%) exceeded 50%, and 5 (7.8%) exceeded 70%.

The source classified 62 of 64 districts (96.9%) as Excess. The term 'excess' follows the classification used in the original data source and does not represent a patient-specific assessment of clinical necessity. Estimate precision was a significant issue with 25 districts (39.1%) with a reliability flag, of which 7 were unreliable estimates with less than 25 observations and 18 were small-sample estimates with 25-49 observations. The average width of the 95% confidence intervals at the district level was 26.15 percentage points. District rankings, therefore, should be interpreted as prompts for additional evaluation and not as absolute performance standards.

Table 3: Distribution and reliability of district C-section estimates, BDHS 2022

Measure	Value	District count	Interpretation
Unweighted mean	44.76%	64	Distribution of district point estimates; not a nationally weighted rate
Median	45.55%	64	Central district estimate
Sample standard deviation	17.81 pp	64	Substantial geographic dispersion
Minimum	10.0%	1	Rangamati
Maximum	77.0%	1	Chuadanga
Above 30%	75.0%	48	Descriptive threshold
Above 50%	40.6%	26	Descriptive threshold
Above 70%	7.8%	5	Descriptive threshold
Source-classified "Excess"	96.9%	62	Source designation; not clinical adjudication
Reliability flagged	39.1%	25	7 unreliable and 18 small-sample estimates
Mean 95% CI width	26.15 pp	64	Wide average uncertainty

Source: BDHS 2022 district estimates reproduced by Khan et al. (2025). The district mean and median are unweighted summaries of survey-weighted point estimates. CI = confidence interval; pp = percentage points.

Figure 4 source data. Ten highest district C-section point estimates, BDHS 2022

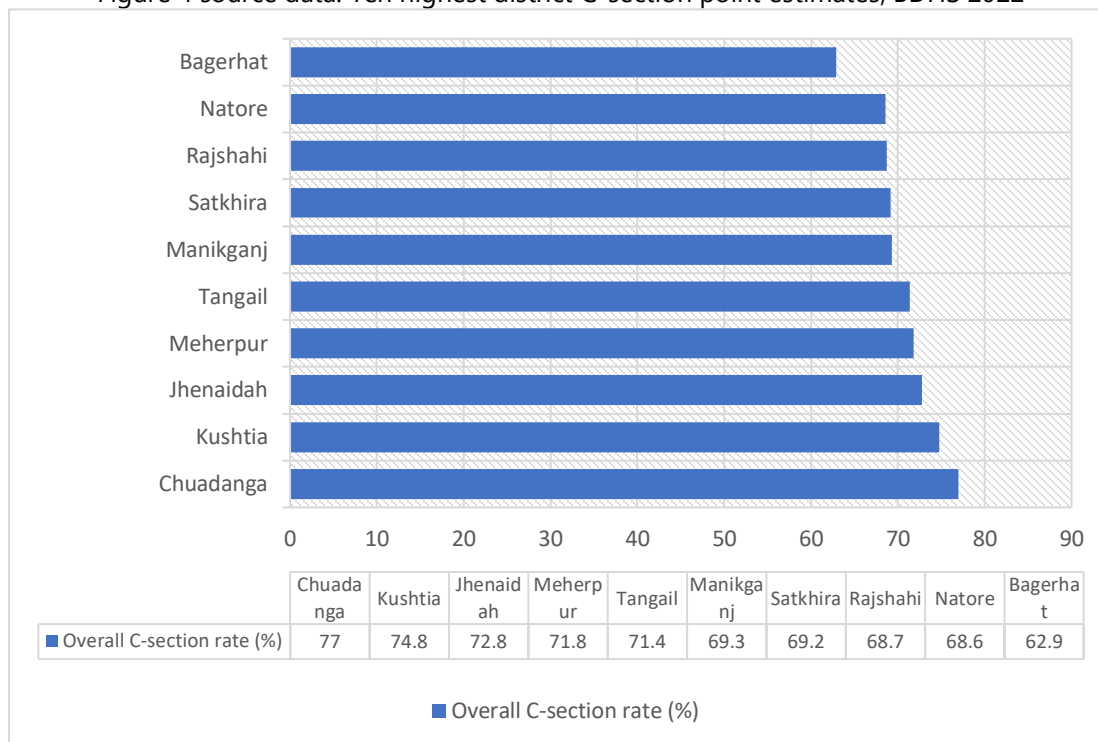


Figure 3: Ten highest district-level C-section estimates in Bangladesh, BDHS 2022

Source: BDHS 2022 district estimates. Exact point estimates are presented in the accompanying source-data table. Interpretation should consider the source 95% confidence intervals and reliability flags.

Highest point estimates were found in some districts in the western and central parts of the country including Chuadanga, Kushtia, Jhenaidah, Meherpur and Tangail. The lowest was in Rangamati, Cox's Bazar, Khagrachhari, Noakhali and Feni. These variations might be due to geographic access, presence of private sector, socioeconomic factors, degree of urbanization, referral patterns, and clinical practice. The cross-sectional district estimates, however, do not constitute a determination of the contribution of any specific mechanism. A high-use and low-use pattern necessitates a differentiated response of a policy nature: high-use contexts should be carefully examined for potential avoidance of intervention, while low use and geographically remote contexts should be safeguarded and expanded in order to ensure timely emergency access.

The observed variation of the district is in line with previous studies on geographic and socioeconomic concentration, such as higher prevalence of cesarean section among women with higher educational status and wealth, and the significant effect of place of delivery on inequality (Kumar & Sharma, 2023; Kundu et al., 2024). However, wide confidence intervals and reliability flags suggest that some apparent differences in district rankings could be due to sampling variation. Local review and service assessment should, therefore, be based on district estimates, not punitive comparison.

4.4 District-year associations

The district-year correlation between C-section rate and MMR was negative ($r = -0.555$) when it was not adjusted for MMR, but positive ($r = 0.234$) when it was adjusted. A corresponding reversal was created by the regression sequence. Pooled ordinary least squares (OLS) estimated 11.60 fewer MMR points for each 10-percentage-point increase in C-section use, and the district fixed-effects model estimated 38.67 fewer points. The coefficient turned positive after the inclusion of year fixed effects, suggesting 10.77 points in MMR. This reversal that national time trends can be common and the pooled estimates can be dominated by them, so the negative aggregated co-trend does not mean that there is a protective effect.

The adjusted two-way fixed-effects model (M4) showed an increase of 12.84 MMR points (95% CI 8.04 to 17.64; $p < .001$) for every 10-percentage-point rise in C-section rate. The lagged model produced a comparable estimate of 12.16 points (95% CI 7.48-16.83; $p < .001$). In the count-model sensitivity analysis, the incidence-rate ratio was 1.025 (95% CI 1.010-1.039; $p < .001$), which translates to an increase of 2.5% in the expected maternal-death rate for every 10-percentage-point increase in C-section use, given the fixed effects and covariates included in the analysis.

Table 4: District-year association models

Model	Specification	Effect scale	Estimate	SE	95% CI	p	N	Fit/status
M1	Pooled OLS	beta per +10 pp	-11.602	1.209	-13.971 to -9.233	<.001	576	$R^2 = 0.308$
M2	District fixed effects	beta per +10 pp	-38.671	1.454	-41.521 to -35.822	<.001	576	$R^2 = 0.546$
M3	District and year fixed effects	beta per +10 pp	10.767	2.750	5.378 to 16.157	<.001	576	$R^2 = 0.055$
M4	Two-way fixed effects and controls	beta per +10 pp	12.840	2.450	8.039 to 17.642	<.001	576	$R^2 = 0.438$
M5	Lagged C-section rate, two-way fixed effects, and controls	beta per +10 pp	12.158	2.385	7.484 to 16.832	<.001	512	$R^2 = 0.443$
M6	PPML with district and year fixed effects and controls	IRR per +10 pp	1.025	-	1.010 to 1.039	<.001	576	Converged (5 iterations)

Note: Linear-model coefficients represent changes in MMR points per 10-percentage-point increase in C-section use. The PPML specification models maternal-death counts with the natural logarithm of live births as an offset. Standard errors are clustered by district. FE = fixed effects; IRR = incidence-rate ratio; OLS = ordinary least squares; PPML = Poisson pseudo-maximum likelihood; pp = percentage points.

Table 5: Changes in the C-section coefficient across linear-model specifications

Model	Coefficient	95% CI
M1: Pooled OLS	-11.60	-13.97 to -9.23
M2: District fixed effects	-38.67	-41.52 to -35.82
M3: District and year fixed effects	10.77	5.38 to 16.16
M4: Two-way fixed effects and controls	12.84	8.04 to 17.64
M5: Lagged C-section rate, two-way fixed effects, and controls	12.16	7.48 to 16.83

Note: Coefficients and 95% confidence intervals are expressed as changes in MMR points per 10-percentage-point increase in C-section use.

Incorporating District fixed effects further strengthened the negative relationship since the national decrease in MMR is not captured. This common national trend was absorbed into the year fixed effects and the direction of the association was reversed. This Simpson-type reversal is a good example of an influence of common-trend confounding. It also demonstrates the need for statistical significance to be interpreted, as both models had a small p-value, but they are both different comparisons and both control different sets of sources of variation.

4.5 Implications for SDG 3.1 and maternal-health policy

Three main conclusions come from the study. First, the rate of cesarean section increased steadily and rapidly, with a high rate of cesarean section in the country. Second, maternal mortality dropped significantly and yet in 2023 was still higher than the SDG 3.1. Thirdly, district coverage by C-sections was highly uneven, and there were many districts estimates that were imprecise. All of these findings help to define the issue as a one of quality, appropriateness and equity: the issue is whether or not C-sections are delivered on time, clinically necessary, safely conducted, and properly supported by referral and postpartum-care systems.

A district-wide reduction target would not reflect the actual district distribution. High use districts need to audit clinical indications, implement review systems, keep a track of primary C-sections, enhance the management of labour, and review financial incentives and public-private practice patterns. There is a need for reliable referral transport, blood supplies, anaesthetic service, surgical resources and full obstetric and neonatal care services in low-use and remote areas. In both settings, monitoring should be focused on haemorrhage, sepsis, anaesthetic complications, maternal near missed, readmission and post-C section outcomes.

5. Conclusion

Despite significant progress in reducing maternal mortality, the MMR remained above the SDG 3.1 target in 2023, and the C-section rate and facility delivery rate rose significantly. National survey estimates are complemented by annual WHO/UN maternal mortality estimates, and estimates for cesarean section for all 64 districts to give a detailed picture of national trends and geographic inequity. The relatively few matched national observations, the requirement to use model-based MMR estimates, the cross-sectional district data, the wide confidence intervals, and the reliability flags for 39.1% of district estimates, however, hinder interpretation. The cross-district summary data were unweighted and did not reflect the national population, and aggregate data were not able to fully capture clinical indications, previous cesarean sections, obstetric problems, referral patterns or the quality of facilities. The findings support a differentiated approach to maternal health rather than a uniform reduction in C-section use. Timely access to medically essential surgery in underserved settings, enhanced emergency obstetric referral and facility capacity, increased surgical safety, and strategies to reduce unnecessary surgeries in high-volume facilities should be implemented to advance SDG 3.1. To ensure the safe and equitable contribution of caesarean section use to further maternal deaths, there is a need for monitoring of clinical indications, maternal outcomes, service readiness, and estimate reliability at a district level.

6. Recommendations

Bangladesh needs to develop strategies at the district and facility level rather than a single target for the reduction of C-section rates. Routine clinical-indication audits, Robson classification reporting and pre-labour and primary C-sections should be implemented in high use settings. Clear oversight of the private sector practices, financial arrangements, and more reliable compliance with evidence-based labour-management procedures should also be considered where possible. The impact of these measures should be measured in terms of maternal and neonatal outcomes, so that reducing potentially avoidable procedures does not result in a delay of medically necessary surgery. For low use, rural and geographically remote settings, the emphasis should be on the promotion of universal comprehensive emergency obstetric and newborn care (u-CEMOC) services available throughout the day. Key investments are in the provision of competent referral transportation, blood transfusion services, surgical and anaesthetic staffs, infection-prevention measures and postoperative monitoring. Future studies would benefit from the creation of a reliable longitudinal district-level database of births, birth and maternal deaths, and C-section with clinical indication, prior cesarean sections, obstetric risk, referral severity, ownership of the facility, and the readiness of the facility. The district-clustered standard errors might then be used, adjustment for common time trends could

be made, and there might be sensitivity analyses for outcome measurement that could be performed with either fixed-effects models or Poisson pseudo-maximum-likelihood models. Monitoring should go beyond MMR severe maternal morbidity, maternal near-miss, haemorrhage, postoperative infection, readmissions and reproductive outcomes later on. An evidence system would help to ensure that c-section is used effectively, safely, and equitably, by ensuring that women receive the appropriate procedure at the appropriate time.

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