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Health outcomes of children born by cesarean delivery: Survey in Rajshahi district, Bangladesh

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Short Report

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Abstract

Background

Bangladesh's caesarean birth rate has increased significantly during the past few decades. Even though C-sections are harmful to mothers and babies, one-third of Bangladeshi deliveries are done this way. This type of investigation is not well documented in Bangladeshi public health literature. The current study investigated the outcome of preschool children's health born via C-section in Bangladesh.

Method

To cover the entire population of Rajshahi, we used a multistage sampling technique to select samples from nine Upazilas and 233 community clinics in Rajshahi district. The study included 540 mothers and their children in total. Researchers employed chi-square tests to determine correlations between categorical variables and logistic regression to pinpoint factors for the health outcomes of children born via caesarean delivery.

Results

The incidence of cesarean delivery was found to be 34.4%. The mean age of the mother was 26.38. According to binary logistic regression analysis, cesarean delivery had a significant impact on children's health outcomes, including child malnutrition ($p = 0.029$), initial breastfeeding ($p < 0.001$), and zinc treatment during diarrhea ($p = 0.006$).

Conclusions

The current study indicates that a C-section birth negatively impacts the health of the infant. Therefore, we advise raising public awareness and implementing strict government rules and regulations to prevent and delay needless caesarean deliveries in Bangladesh.

Introduction

Cesarean section (C-section) is a life-saving surgery performed when the mother's or child's lives are in danger (1). C-section rates have risen dramatically worldwide, from 12.1% in 2000 to 21.1%, while it is also projected that by 2030, 29% or a third of childbirths are likely to undergo cesarean (2). The latest analysis of 154 countries showed that 21.1% of women worldwide gave birth by C-section, with averages ranging from 5% in Sub-Saharan Africa to 42.8% in Latin America. Eastern and Southern Asia experienced the greatest increases (44.9 and 19.0% age point increase, respectively) (3). C-sections

have increased thirteen-fold in Bangladesh, from 3.5% in 2004 to 45% in 2022 (4). However, proportionately, the number of babies delivered by C-section has increased without maternal medical or obstetric indication (5). The World Health Organization (WHO) recently reconsidered accessible evidence that women need to be delivered by C-section when the condition is medically inevitable (6). In Bangladesh, there are numerous risks linked with C-sections of mothers, such as maternal education, age, wealth index, age at first birth, the place of residence, parity, ANC visit, and husband occupation (7), (8).

Mothers who have gone under C-sections encountering some short-term and long-term health complications increased risk of placental abruption, placenta previa, infection, hemorrhage, visceral injury, venous thromboembolism, and subfertility and several subsequent pregnancy risks such as placenta previa, uterine rupture, and stillbirth (9). Children who have been given birth by C-section babies more likely to suffer from food allergies, type 1 diabetes, obesity, anemia, Crohn's disease, asthma, even in some cases children might have autism spectrum disorders and attention deficiencies (9–13). Therefore, it is an urgent need to stop and avoid unnecessary C-section deliveries to foster the achievement of the global target of SDGS; lowering C-section rates will not be obtained.

Hasan MN et. al. study using BDHS 2011 to 2014 data revealed that the incidence of caesarian delivery increased from 17.95% in 2011 to 23.33% in 2014. This study did not found any significant effect of caesarian delivery on childhood diseases in both surveys. Only in 2014 BDHS, the study found that C-section raises the risk of childhood disease by 5%. However, the risk of childhood disease differed significantly in all survey years by division, child’s age, and child’s size at birth (14). Rahman M et al. study showed that the mean weight and age of mothers were 53.1 kg and 25.1 years, respectively. Children who were born by cesarean operation had a greater chance of reporting frequent illness, breathing problems, and lower hours of sleeping and food demand (15). However, the study did not explore the children's specific age. However, to the best of our search in different platforms, we found no research that has been conducted in Bangladesh to explore the child health outcome of C-sections on preschool children. The principal objectives of this study are two-fold: (i) to find the prevalence of caesarian delivery in Bangladesh; and (ii) to explore the child health outcome of C-section delivery on preschool children in the Rajshahi district of Bangladesh.

Methods

Study design

This study employed a cross-sectional approach, collecting data from the field. The study focused on the Rajshahi district, situated in the northwestern region of Bangladesh, covering an area of 2425.37 square kilometres with a population of 2,915,013, comprising 37.56% urban and 62.44% rural residents (BBS, 2022, adjusted on July 23, 2022), which was purposively selected. The primary participants were mother-pair preschool children (aged 6–59 months) residing within this district's catchment area of a community clinic. Data collection took place through field surveys conducted from February to June 2017 within the catchment area's community clinic, with interviews administered by a qualified community health worker to the selected respondents.

Exclusion criteria

All currently pregnant or seriously sick mothers and those who did not receive antenatal care service and lived separately from their under-5 children were excluded from the study.

Sample size determination

The samples were chosen using a multistage sampling procedure, while sample size was calculated using the following formula (16):

$$n = \frac{N}{1 + Nd^2}$$

Where N is the household size (in this case, N = 2,71,302), d is the marginal error (d is taken to be equal to 0.05 in this study), and n is the sample size. In this study, the 95% confidence level was chosen. This formula provided that 399 respondents were required for this study. Finally, a total sample of 540 mother-child pairs was taken for final data enumeration.

Sample selection procedure

In Rajshahi district, there are 233 community clinics spread across nine Upazilas (BBS, District Statistics, 2011). The sampling method employed was multistage random sampling, encompassing the entire population of these Upazilas. In the first stage, two community clinics were randomly selected from each Upazila, totalling 18 (9x2) community clinics. Subsequently, in the second stage, two villages were randomly chosen from the catchment areas of each selected community clinic, resulting in the selection of

36 (18x2) villages. 17 households were selected from each village by simple random sampling. We identified the households with children under-5 years and their mothers from the community clinics database. Mothers and their children were identified using their identification number (holding number or listing), obtained from the respective UP. One was selected through a lottery in cases with multiple mothers within the same household. Initially, a total number of 612 households were selected, but 72 (12%) households did not agree to participate in the study. If there was more than one mother with under-5 children in a household, we selected one mother with her child randomly. If the selected mother had more than one under-5 children, last born child was considered. In the study, a total of 540 mothers and their 540 preschool children were included as the sample for the study.

Dependent variable

Cesarean delivery was the primary outcome variable for this study, while different health-related complications in the children were also simultaneously measured. The mothers were asked, "Did you deliver your last baby by a cesarean?" (7) if it was (i) Yes (Caesarian delivery, coding as 1) or (ii) No (Vaginal delivery, coding as 0).

Exposure variables

We selected covariates that we hypothesized could be associated with impact for caesarian delivery, including child malnutrition (no, yes); stunting of the children (not stunted, stunted); wasting of the children (not wasting [SD $\geq$ 1 WHZ], wasting [SD =-2 WHZ]); initial breastfeeding (no, yes); jaundice complications after the birth (no, yes); pneumonia problem after the birth (no, yes); unable to suck a problem after the birth (no, yes); exclusive breastfeeding within 0–6 months (no, yes); Zink treatment during diarrhea (no, yes); receive antibiotic during pneumonia (no, yes); and continue breastfeeding within 6–23 months (no, yes) were considered as the independent variables. Stunting is a term used to indicate children under 5 years of age with a height-for-age <-2 standard deviation of the median of the standard curve (17). Wasting is defined among infants under 5 years of age if weight-for-height is below 2 standard deviation from the WHO median value (17). Child malnutrition is identified if MUAC $<$ 125 mm for children 6–59 months (17).

Statistical analysis

All statistical tests are completed using Stata v 14.2. To justify the cross-sectional survey design, sampling weights were utilized. Data cleaning procedures were conducted before analysis, including handling missing values and recoding variables as necessary. We used mean and interquartile range to describe participants' characteristics. The bivariate connotation between child health outcome factors and C-section delivery was examined by

Pearson’s Chi-squared ($\chi 2$) test. Only the significant variables in bivariate analysis were entered into the regression models. Subsequently, odds ratio (OR) and its 95% confidence interval (95% CI) were found using logistic regression models to estimate the associations between the child health outcome variables and caesarian delivery. To detect the multicollinearity problem, we used the standard error among independent variables (18) and there is no multicollinearity problem in this analysis. We performed two-tailed statistical tests, with a significance p-value of less than 0.05.

Results

Prevalence of C-section delivery

In this research, 540 mothers were studied to determine the incidence of cesarean delivery and its impact on infants. The incidence of C-section delivery in Rajshahi district of Bangladesh was 34.4% during the survey period. As shown in Fig. 1, the distribution of cesarean delivery varies significantly by maternal age group. The highest prevalence of cesarean delivery is observed in maternal aged 25–29 years (38.2%), followed by those aged 20–24 years (30.1%), and 30–34 years (17.2%).

Socio-demographic characteristics of the respondent mothers

The median (IQR) mother's age was 26.0 (22.0–30.0) years. Besides, maternal median (IQR) height and weight were 152.0 (149.5–157.0) cm and 50.0 (45.0–56.0) kg, respectively. The monthly median (IQR) maternal family income and expenditures were 6000.0 (4000.0-10000.0) BDT and 6000.0 (4000.0-8000.0), respectively (Table 1).

Table 1
Socio-demographic characteristics of the respondents

Characteristics	Median (IQR)	95% CI for mean	
		Lower bound	Upper bound
Maternal age(year)	26.0 (22.0–30.0)	25.95	26.82
Maternal weight (kg)	50.0 (45.0–56.0)	50.18	51.66
Maternal height (cm)	152.0 (149.5–157.0)	152.25	153.34
Children ever born	2.0 (1.0–2.0)	1.65	1.76
Number of antenatal visit	1.0 (1.0–3.0)	1.54	1.77
Monthly family income (BDT)	6000.0 (4000.0-10000.0)	7736.39	8771.75
Monthly family expenditure (BDT)	6000.0 (4000.0-8000.0)	6482.53	7158.95

Table 2
Demographic characteristics of the children who were born via cesarean delivery

Characteristics	Subject (N)	Crude Mean (± SD)	95% CI for mean
Child age (month)	186	27.80 (± 14.75)	25.67–29.93
Child weight (kg)	186	10.77 (± 3.11)	10.32–11.22
Child height (cm)	186	80.58 (± 12.82)	78.73–82.43

Table 2 shows that the average age of children born by cesarean section was 27.80 months. Children's average height and weight were found to be 80.58 cm and 10.77 kg, respectively.

Table 3
The bivariate association between child health outcome factors and cesarean delivery

Child health indicators	N (%)	Caesarian delivery		χ2-values	P-values
		Yes (%)	No (%)		
Child malnutrition				5.33	**0.021**
No	493 (91.3)	177 (95.2)	316 (89.3)		
Yes	47 (8.7)	9 (4.8)	38 (10.7)		
Child Stunting				0.61	**0.434**
Not Stunted	304 (56.3)	109 (58.6)	195 (55.1)		
Stunted	236 (43.7)	77 (41.4)	159 (44.9)		
Child Wasting				2.61	**0.106**
Not Wasting	389 (72.1)	142 (76.3)	247 (69.7)		
Wasting	151 (27.9)	44 (23.7)	107 (30.3)		
Initial breastfeeding				19.57	**< 0.001**
No	29 (5.4)	21 (11.3)	8 (2.3)		
Yes	511 (94.6)	165 (88.7)	346 (97.7)		
Jaundice complications after the birth				0.82	**0.366**
No	493 (91.3)	167 (89.8)	326 (92.1)		
Yes	47 (8.7)	19 (10.2)	28 (7.9)		
Pneumonia problem after the birth				0.01	**0.995**
No	482 (89.3)	166 (89.3)	316 (89.3)		
Yes	58 (10.7)	20 (10.7)	38 (10.7)		
Unable to suck a problem after the birth				0.87	**0.351**
No	532 (98.5)	182 (97.8)	350 (98.9)		
Yes	8 (1.5)	4 (2.2)	4 (1.1)		
Exclusive breastfeeding (0–6 months)				0.07	**0.792**
No	31 (5.7)	10 (5.4)	21 (5.9)		
Yes	509 (94.3)	176 (94.6)	333 (94.1)		
Zink treatment during diarrhea				6.82	**0.009**

Notes: ‘N, total’; ‘%, percentages’; ‘CI, confidence interval’

Child health indicators	N (%)	Caesarian delivery		χ2-values	P-values
		Yes (%)	No (%)		
No	277 (51.3)	81 (43.5)	196 (55.4)		
Yes	263 (48.7)	105 (56.5)	158 (44.6)		
Receive antibiotic during pneumonia				1.22	**0.268**
No	365 (67.6)	120 (64.5)	245 (69.2)		
Yes	175 (32.4)	66 (35.5)	109 (30.8)		
Continue breastfeeding (6–23 months)				0.90	**0.343**
No	111(20.6)	34 (18.3)	77 (21.7)		
Yes	429 (79.4)	152 (81.7)	277 (78.3)		
Notes: ‘N, total’; ‘%, percentages’; ‘CI, confidence interval’					

Table 3 describes the prevalence of essential interventions and the persistent challenges of nutrition and health impact on children due to cesarean delivery in Rajshahi district, Bangladesh. The highest prevalence (56.4%) is for zinc treatment during diarrhea. Child stunting (41.4%) and receiving antibiotics during pneumonia (35.5%) are also significant concerns. Additionally, child wasting accounts for 23.7%. Breastfeeding-related indicators show that 18.3% continue breastfeeding, 11.3% did not receive initial breastfeeding, and 5.4% were not exclusively breastfed. Pneumonia problems after birth affect 10.7% of children, whereas child malnutrition is observed in 4.8%.

Bivariate analysis showed that child malnutrition, initial breastfeeding, zink treatment during diarrhea significantly impacted ($p < 0.001$) under-five caesarian children [see Table 3].

Table 4
Odds ratio of children's health outcome among mothers who have performed caesarean delivery either vaginal delivery

Children's health outcome	OR (95% CI)	p-values
Child malnutrition		
Vaginal delivery	Reference	
Caesarean delivery	2.36 (1.12–5.01)	0.024
Initial breastfeeding		
Vaginal delivery	Reference	
Caesarean delivery	0.18 (0.08–0.42)	< 0.001
Zink treatment during diarrhea		
Vaginal delivery	Reference	
Caesarean delivery	1.61 (1.12–2.29)	0.009
Notes: 'OR, odd ratios'; 'CI, confidence interval'		

Outcome factors of caesarian child health

The logistic regression analysis, as presented in Table 4, identified several child health-related outcome factors independently associated with cesarean delivery. Malnutrition was 2.36 times more common in children born by cesarean section (AOR: 2.36, 95% CI: 1.12–5.01, $p = 0.024$). Children born via cesarean delivery had significantly lower odds of receiving initial breastfeeding (AOR: 0.18, 95% CI: 0.08–0.42, $p < 0.001$), suggesting a strong negative impact of cesarean birth on early breastfeeding initiation. Additionally, children who received zinc treatment during diarrhea had a 1.61 times higher likelihood of being delivered via cesarean section (AOR: 1.61, 95% CI: 1.12–2.29, $p = 0.009$).

Discussion

The observed prevalence of cesarean sections (C-sections) in Bangladesh is 34.4%, which closely mirrors recent national data, and substantially exceeds the regional averages by two to three times and indicates a significant upward trend within the country. The Bangladesh Demographic and Health Survey (BDHS) indicate that the C-section rate was approximately 33% in 2017–2018. Furthermore, a report highlights an increase in the C-section rate from 18% in 2011 to 45% by 2022, with a peak of 36.9% recorded in urban populations (19). In a comparative context, Bangladesh exhibits one of the highest rates of C-sections in South Asia. Specifically, Sri Lanka reports a rate of 30%, the Maldives falls within the range of 32% to 41%, and certain urban regions of India present rates between

36% and 60%. Notably, however, India’s national average remains lower at 14% (20, 21). In contrast, Pakistan shows moderate levels of C-sections, ranging from 12% to 23%, while Nepal's population-level rates are considerably lower at 4.6%. It is worth noting that these rates increase significantly in institutional settings, with rates reaching 17.5%, and in tertiary hospitals, where they may rise to as high as 50% (20). In 1985, the World Health Organization stated, "There is no justification for any region to have C-section rates higher than 10–15%" (22), implying that C-sections should be performed only when medically necessary (6).

Breastfeeding provides immunological benefits, promotes cognitive development, and protects against infectious diseases, rendering it beneficial to the well-being of infants (23). Early initiation of breastfeeding indicates mother’s breast milk to infants within one hour of birth which ensures receiving colostrum in the infant. Current substantiation indicates that infants placed in early skin-to-skin connection with their mother also appear to network more with their mothers and cry less (24). Breast milk not only helps prevent obesity in later stages of life but also supports the psychosocial development of infants (25). It contains vital nutrients and immunological and anti-inflammatory properties that protect mothers and children from various infections and diseases (26, 27). Our findings indicated a significant association between cesarean births and the early initiation of breastfeeding, aligning with a study conducted in Calgary, Alberta (28). In contrast, a Tanzanian study reported that cesarean births were associated with a 78% lower likelihood of early breastfeeding initiation compared to vaginal births (29).

Children born via C-section are more susceptible to respiratory distress, severe acute malnutrition or poor childhood growth, and metabolic issues (30), (15). Additionally, children born through C-section delivery had significantly higher rates of underweight compared to those born through natural delivery (31). Our study results indicate that caesarean birth is significantly associated with child malnutrition. A previous study in Bangladesh shows that C-section births have a 12% higher likelihood of double burden of malnutrition at the household level with one unit change in time (32). Moreover, Chen and Tan revealed that the risk of child under-nourishment was 1.16 times higher for C-section deliveries compared to normal deliveries(33).

Zinc is an essential micronutrient associated with over 300 biological functions. Marginal zinc deficiency states are common among children living in poverty and exposed to diets either low in zinc or high in phytates that compromise zinc uptake. These children are at increased risk of morbidity due to infectious diseases, including diarrhoea and respiratory infection. Children aged under-five children and those exposed to zinc-deficient diets will benefit from either daily supplementation of zinc or a 10 to 14-day course of zinc treatment for an episode of acute diarrhoea (34).Infants born via C-section experience delayed colonization of the Bacteroidetes phylum, reduced Th1 responses, and decreased

microbial diversity during the first two years of life, where variation exists in the neonate gut microbiota (35, 36). Our study revealed that cesarean-born children had higher odds of requiring zinc treatment for diarrhea than those delivered vaginally. These findings are consistent with studies conducted in New Zealand and Japan (37), (38). Furthermore, it has been observed that infants delivered by C-section harbor fewer bifidobacteria at an early age (39), increasing their risk for systemic connective tissue disorders, juvenile arthritis, inflammatory bowel disease, and immune deficiencies (40). Under five children are especially prone to zinc deficiency because of poor dietary quality and increased faecal loss of zinc due to repeated gastrointestinal infections (41). The natural sources of zinc are: red meat, poultry, beans, nuts, whole grain, dairy products, and certain sea-foods, such as oysters (42).

Strengths and limitations

Primary data were utilized to study the child health outcome via cesarean delivery on preschool children in Bangladesh. This study precisely reveals the scenario of the cesarean delivery impact among children living in the northern part of Bangladesh. Child health outcomes on cesarean delivery were examined using logistic regression analysis.

Despite the above strengths, we acknowledge some limitations of this study. First, we considered only live children who were delivered at hospitals/clinics and at home in the Rajshahi district, Bangladesh. Second, due to its reliance on primary data analysis, this study is limited by some data that was gathered using the recall bias technique. Besides, this was a cross-sectional study; it was not possible to determine the temporal link between the outcome and independent variables. Third, due to information limitations, the literature mentioned various health outcome factors on preschool children, not all of which were considered in this analysis.

Conclusions

We considered 540 mothers and their under-five children living in the Rajshahi district in Bangladesh for investigating the health outcome of C-section delivery on preschool children. The prevalence of cesarean delivery among mothers living in rural areas of the Rajshahi district in Bangladesh was 34.4%. The C-section delivery in the current study has remained higher over time than recommended by the World Health Organization (WHO). Our investigation shows that C-sections adversely impact initial breastfeeding and increase the likelihood of zinc treatment during diarrhea for preschool children. Addressing these issues is crucial for achieving Sustainable Development Goals (SDGs) by 2030. So, it is high time to take necessary steps against the destructive consequences of unnecessary C-sections in Bangladesh through some urgent clinical practices.

Additionally, pregnant women and their household members could play a role in avoiding the cesarean delivery consequence by maintaining perfect antenatal care.

Declarations

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Authors' Contributions

MAH conceptualized the study design. **MRK** collected the data**. MAH** completed the data validation and formal analysis. **MAH, MRK, MSI and MMT** were drafting the original manuscript. **MAH, MSI, MRK, and MMT** critically reviewed the manuscript. **MAH** supervised the whole study. All authors read and approved the final study for submission.

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Data Availability: Data are accessible upon appropriate request. All such requests can be sent to authors email address: mel.dascoh@gmail.com

References

1. Zakerihamidi M, Roudsari RL, Khoei EM. Vaginal delivery vs. cesarean section: a focused ethnographic study of women's perceptions in the north of Iran. Int J community based Nurs midwifery. 2015;3(1):39.

2. Boerma T, Ronsmans C, Melesse DY, Barros AJD, Barros FC, Juan L, et al. Global epidemiology of use of and disparities in caesarean sections. Lancet. 2018;392(10155):1341–8.
3. Betran AP, Ye J, Moller AB, Souza JP, Zhang J. Trends and projections of caesarean section rates: global and regional estimates. BMJ Glob Heal. 2021;6(6):e005671.
4. National Institute of Population Research and Training (NIPORT) and ICF. Bangladesh Demographic and Health Survey 2022: Key Indicators Report. [Internet]. Dhaka, Bangladesh, and Rockville, Maryland, USA; 2023. Available from: https://dhsprogram.com/pubs/pdf/PR148/PR148.pdf
5. Thomas J, Paranjothy S. The national sentinel caesarean section audit report. Natl Sentin Caesarean Sect Audit Rep. 2001;
6. Organization WH. WHO statement on caesarean section rates. In: WHO statement on caesarean section rates. 2015.
7. Hasan F, Alam MM, Hossain MG. Associated factors and their individual contributions to caesarean delivery among married women in Bangladesh: analysis of Bangladesh demographic and health survey data. BMC Pregnancy Childbirth. 2019;19(1):433.
8. Rahman MM, Haider MR, Moinuddin M, Rahman AE, Ahmed S, Khan MM. Determinants of caesarean section in Bangladesh: Cross-sectional analysis of Bangladesh Demographic and Health Survey 2014 Data. PLoS One. 2018;13(9):e0202879.
9. Keag OE, Norman JE, Stock SJ. Long-term risks and benefits associated with cesarean delivery for mother, baby, and subsequent pregnancies: Systematic review and meta-analysis. PLoS Med. 2018;15(1):e1002494.
10. Magne F, Puchi Silva A, Carvajal B, Gotteland M. The elevated rate of cesarean section and its contribution to non-communicable chronic diseases in Latin America: the growing involvement of the microbiota. Front Pediatr. 2017;5:192.
11. Si K yi, Li H tian, Zhou Y bo, Li Z wen, Zhang L, Zhang Y li, et al. Cesarean delivery on maternal request and common child health outcomes: A prospective cohort study in China. J Glob Health. 2022;12:11001.
12. Begum T, Rahman A, Nababan H, Hoque DME, Khan AF, Ali T, et al. Indications and determinants of caesarean section delivery: Evidence from a population-based study in Matlab, Bangladesh. PLoS One. 2017;12(11):e0188074.
13. Zhang T, Sidorchuk A, Sevilla-Cermeño L, Vilaplana-Pérez A, Chang Z, Larsson H, et al. Association of cesarean delivery with risk of neurodevelopmental and psychiatric disorders in the offspring: a systematic review and meta-analysis. JAMA Netw open. 2019;2(8):e1910236–e1910236.
14. Hasan MN, Chowdhury MAB, Jahan J, Jahan S, Ahmed NU, Uddin MJ. Cesarean delivery and early childhood diseases in Bangladesh: An analysis of Demographic and

Health Survey (BDHS) and Multiple Indicator Cluster Survey (MICS). PLoS One. 2020;15(12):e0242864.

15. Rahman M, Khan N, Rahman A, Alam M, Khan A. Long-term effects of caesarean delivery on health and behavioural outcomes of the mother and child in Bangladesh. J Heal Popul Nutr. 2022;41(1):45.
16. Rana M, Sayem A, Karim R, Islam N, Islam R, Zaman TK, et al. Assessment of knowledge regarding tuberculosis among non-medical university students in Bangladesh: a cross-sectional study. BMC Public Health. 2015;15(1):716.
17. World Health Organization. WHO child growth standards : length/height-for-age, weight-for-age, weight-for-length, weight -for-height and body mass index-for-age : methods and development. 2006; Available from: https://apps.who.int/iris/handle/10665/43413
18. Chan YH. Biostatistics 202: logistic regression analysis. Singapore Med J. 2004;45(4):149–53.
19. Sizear MI, Rashid M. Urgent need to address increasing caesarean section rates in lower-middle-income countries like Bangladesh. Front Glob women's Heal. 2024;5:1365504.
20. Verma V, Vishwakarma RK, Nath DC, Khan HTA, Prakash R, Abid O. Prevalence and determinants of caesarean section in South and South-East Asian women. PLoS One. 2020;15(3):e0229906.
21. Roy A, Paul P, Chouhan P, Rahaman M, Kapasia N. Geographical variability and factors associated with caesarean section delivery in India: a comparative assessment of Bihar and Tamil Nadu. BMC Public Health. 2021;21(1):1715.
22. Organization WH. Appropriate technology for birth. Lancet. 1985;2:436–7.
23. Nixarlidou E, Margioula-Siarkou C, Almperis A, Vavoulidis E, Laganà AS, Dinas K, et al. Clinical significance and main parameters promoting the breast-feeding strategy. Med Int. 2024;4(2):14.
24. World Health Organization (WHO). WHO. 2023 [cited 2023 Aug 9]. Early initiation of breastfeeding to promote exclusive breastfeeding. Available from: https://www.who.int/tools/elena/interventions/early-breastfeeding
25. Patra K, Hamilton M, Johnson TJ, Greene M, Dabrowski E, Meier PP, et al. NICU human milk dose and 20-month neurodevelopmental outcome in very low birth weight infants. Neonatology. 2017;112(4):330–6.
26. Lawrence RA, Lawrence RM. Breastfeeding: A guide for the medical professional. Elsevier Health Sciences; 2021.
27. Gouveri E, Papanas N, I Hatzitolios A, Maltezos E. Breastfeeding and diabetes. Curr Diabetes Rev. 2011;7(2):135–42.

28. Hobbs AJ, Mannion CA, McDonald SW, Brockway M, Tough SC. The impact of caesarean section on breastfeeding initiation, duration and difficulties in the first four months postpartum. BMC Pregnancy Childbirth. 2016;16(1):90.
29. Exavery A, Kanté AM, Hingora A, Phillips JF. Determinants of early initiation of breastfeeding in rural Tanzania. Int Breastfeed J. 2015;10(1):27.
30. Saaka M, Hammond AY. Caesarean section delivery and risk of poor childhood growth. J Nutr Metab. 2020;2020(1):6432754.
31. Das U, Rout NR. Impact of normal vs. caesarean deliveries on child nutritional status and mortality in India: insights from NFHS-5 data. BMC Pediatr. 2024;24(1):781.
32. Sutopa TS, Bari W. How does mode of delivery associate with double burden of malnutrition among mother–child dyads?: a trend analysis using Bangladesh demographic health surveys. BMC Public Health. 2022;22(1):1243.
33. Chen H, Tan D. Cesarean section or natural childbirth? cesarean birth may damage your health. Front Psychol. 2019;10:351.
34. Larson CP, Roy SK, Khan AI, Rahman AS, Qadri F. Zinc treatment to under-five children: applications to improve child survival and reduce burden of disease. J Health Popul Nutr. 2008;26(3):356.
35. Jakobsson HE, Abrahamsson TR, Jenmalm MC, Harris K, Quince C, Jernberg C, et al. Decreased gut microbiota diversity, delayed Bacteroidetes colonisation and reduced Th1 responses in infants delivered by caesarean section. Gut. 2014;63(4):559–66.
36. Palmer C, Bik EM, DiGiulio DB, Relman DA, Brown PO. Development of the human infant intestinal microbiota. PLoS Biol. 2007;5(7):e177.
37. Akagawa S, Tsuji S, Onuma C, Akagawa Y, Yamaguchi T, Yamagishi M, et al. Effect of delivery mode and nutrition on gut microbiota in neonates. Ann Nutr Metab. 2019;74(2):132–9.
38. Wilson BC, Butler ÉM, Grigg CP, Derraik JGB, Chiavaroli V, Walker N, et al. Oral administration of maternal vaginal microbes at birth to restore gut microbiome development in infants born by caesarean section: A pilot randomised placebo-controlled trial. EBioMedicine. 2021;69.
39. Huurre A, Kalliomäki M, Rautava S, Rinne M, Salminen S, Isolauri E. Mode of delivery–effects on gut microbiota and humoral immunity. Neonatology. 2008;93(4):236–40.
40. Sevelsted A, Stokholm J, Bønnelykke K, Bisgaard H. Cesarean section and chronic immune disorders. Pediatrics. 2015;135(1):e92–8.
41. Fontaine O. Effect of zinc supplementation on clinical course of acute diarrhoea. J Health Popul Nutr. 2001;19(4):339–46.
42. Ross AC, Caballero B, Cousins RJ, Tucker KL. Modern Nutrition in Health and Disease:. Jones & Bartlett Learning; 2020.

Figures

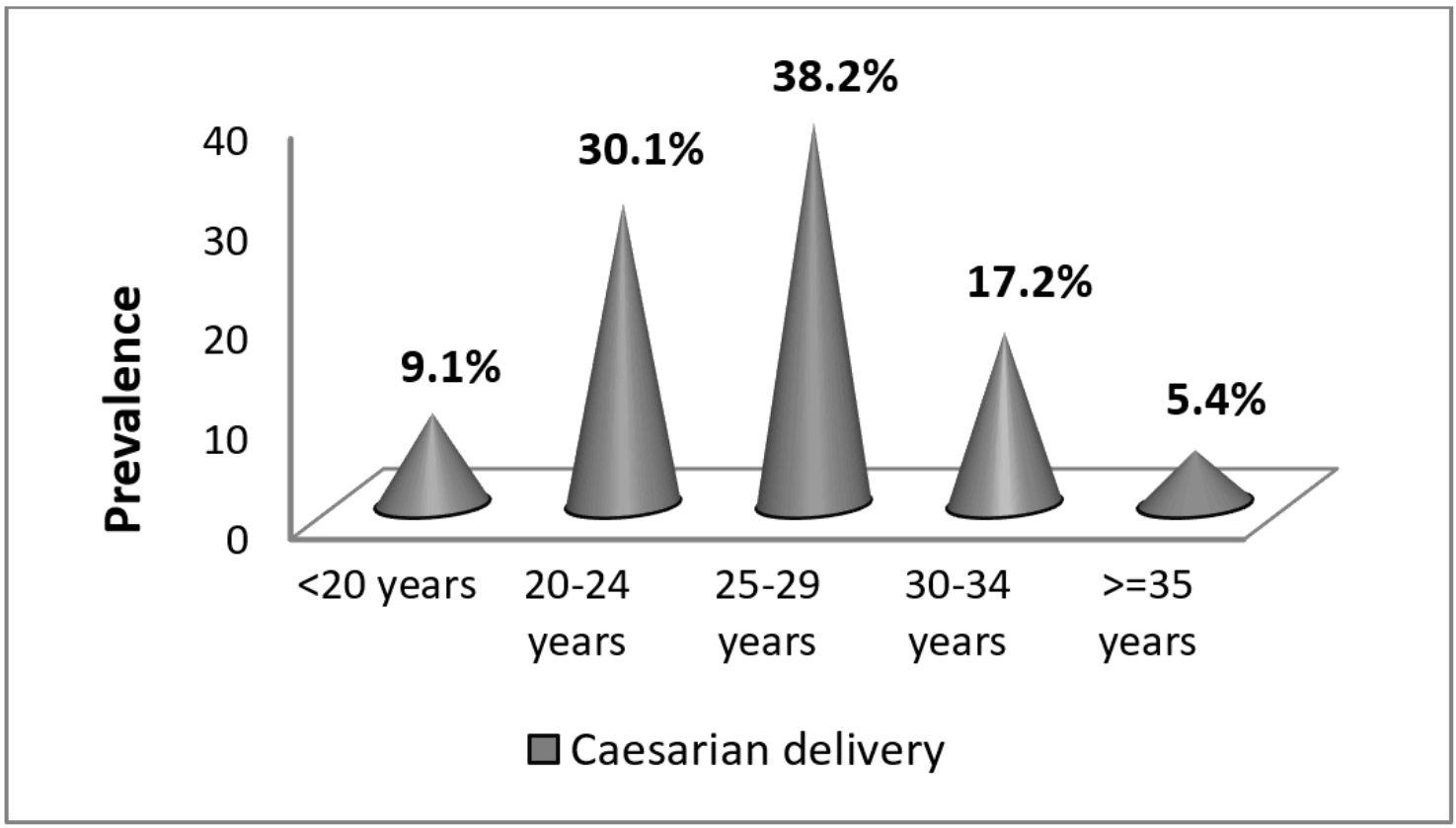


Figure 1

Prevalence of cesarean delivery categorized by maternal age