**Association between caesarean delivery and early childhood diseases in Bangladesh: an application of propensity score method**

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**Abstract**

**Introduction**

The rate of cesarean delivery (C-section) has increased worldwide including Bangladesh. Since the C-section is major surgery, it has a negative impact on the health of the mother and child. However, research on this area in ​​Bangladesh is scarce. Our objective was to inspect the association between C-section versus vaginal delivery and childhood diseases using negative binomial (NB) regression and propensity score (PS) method.

**Methods**

We used the latest available nationally representative data from a multiple indicator cluster survey (MICS, 2012-13) and also Bangladesh Demographic and Health Survey (BDHS, 2014). After considering the inclusion and exclusion criteria, 7902 children were eligible for final analysis from MICS data and 4557 children were eligible for final analysis from BDHS data. The outcome variable was created using childhood diseases such as fever, fast and/or difficulty of breathing, blood in stools and diarrhea. Important confounding factors such as the age of child, child ever been breastfed, child's weight during survey, weight at birth, child's length or height, area, division, sex (child), mother's education, age, body mass index, religion of household head, and wealth index quintile were considered. We used the PS method to analyses our data. For sensitivity, we also used NB regression with a log link in which the outcome was a count variable.

**Results**

We found 19.1% and 23.3% of children were born in the C-section and 80.9% and 70.7% of children were born in normally (vaginal delivery) in MICS and BDHS surveys respectively. From the PS method, we found the crude (the only type of delivery variable in the model) risk ratios (RR) for the C-section were 1.60 (95% confidence interval (CI): 1.30-1.97) and 1.11 (95% CI: 1.01-1.23) for MICS and BDHS, respectively. RR for adjusted (type of delivery and propensity scores in the model) model was 1.19 (CI: 0.99-1.43) for MICS and 1.17 (1.05-1.29) for BDHS. Almost similar findings were observed in the case of the NB regression model using the count outcome (e.g., the RR was 1.06 (95% CI: 1.02-1.09) for MICS and 1.08 (CI: 0.97-1.19) for BDHS and adjusted risk ratio (ARR) was 1.02 (95% CI: 0.98-1.06) for MICS and 1.15 (CI:1.05-1.27) for BDHS, respectively.

**Conclusion**

Although the results indicate that children born in C-section compare to the vaginal delivery were at increased risk for developing childhood disease, we did not identify any significant causal association between the type of delivery and the childhood diseases in some models. However, we recommend increasing public awareness of the negative impact of unnecessary cesarean delivery in Bangladesh.

**Keywords:** Caesarean section; vaginal delivery; childhood disease; MICS, BDHS

**1. Introduction**

Cesarean delivery (C-section) is a surgical procedure that is often performed to reduce the risks for the mother and fetus during vaginal delivery (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4280556/>). However, today, the C-section is considered to be relieving from labor pain and people have a common belief that C-section is painless, safer, and healthier than vaginal delivery. Recently, it has become a preferred choice as mode of delivery among women (<https://www.ncbi.nlm.nih.gov/pubmed/21547801>). But C-section should only recommend when the life of the mother or fetus is at risk.

The C-section is rapidly increasing in many developed and developing countries (Gomes et al. 1999; Leung et al. 2001). In recent years as a major surgery related to immediate risk of maternal and childbirth and may be important for pregnancy and long-term effects on child. C-section is rapidly increasing in many developed and developing countries. In fact, more than half of women voluntarily undergo C-section (<https://scholar.google.com/scholar_lookup?title=Danforth%E2%80%99s+obstetrics+and+gynecology&author=RS+Gibbs&publication_year=2008&>).

This choice is influenced by a number of factors, including ways to prevent labor pain, it is safer, healthier than vaginal delivery(<https://www.ncbi.nlm.nih.gov/pubmed/10728843/>), fear of vaginal delivery(<https://www.ncbi.nlm.nih.gov/pubmed/25949249/>) , incorrect cultural assumptions about C-Section delivery(<https://www.ncbi.nlm.nih.gov/pubmed/17230288/>), and closure of the uterine tubes(<https://www.ncbi.nlm.nih.gov/pubmed/18842327/>).

In contrast, most women prefer natural birth due to personal beliefs, cultural customs and values(https://www.ncbi.nlm.nih.gov/pubmed/25949249/), faster recovery after delivery(<https://www.ncbi.nlm.nih.gov/pubmed/18842327/>), economic problems(<https://www.ncbi.nlm.nih.gov/pubmed/25949250/>), lack of concern about the safety of mother and baby and fear of anesthesia(https://www.ncbi.nlm.nih.gov/pubmed/15994631/).

A trend analysis based on data from 121 countries reported that, from 1990 to 2014, the average C-section rates increased by 12.4% and the average annual rate increased by 4.4% (Betrán et al. 2016). A 2004-2008 world health organization (WHO) survey recorded an average global rate of C-section was 25.7% in which 27.3% in Asia, 19.0% in Europe and 29.2% in Latin America (Lumbiganon et al. 2010; Villar et al. 2006). As stated by WHO, there is no justification for any region to have a caesarean rate higher than 10 -15%, which weighs a serious reason for worry in most of the countries worldwide (Rahman et al. 2015). In Bangladesh, the C-section (either clinically necessary or unnecessary) rate increased from 3.5% in 2004 to 23% in 2014, (Khan et al. 2017).

Women experiencing the C-section delivery without a clear intimation for the process have a risk of major morbidity including cardiac arrest, hysterectomy, puerperal infection, thromboembolism, wound hematoma, anaesthetic complications than those undergoing planned vaginal delivery (Yuan et al. 2016). In addition, babies born in C-section are at risk of developing asthma (Ajslev et al. 2011; Darmasseelane et al. 2014), type 1 diabetes (Ajslev et al. 2011; Darmasseelane et al. 2014), crohn's disease (Yuan et al. 2016), allergic diseases (Ajslev et al. 2011), immune deficiencies, and leukaemia and so on. A study was performed to examine the caesarean delivery and its correlates in Northern Region of Bangladesh (Rahman et al. 2015). In this study, authors showed that the factors such as risk of having a previous C-section, prolonged labour, higher educational level, mother age 25 years and above, lower order of birth, length of baby more than 45 cm and irregular intake of balanced diet were significantly correlated with the C-section (Rahman et al. 2015). Another study found that mother being older, obese, residing in urban areas, first birth, maternal perception of large newborn size, husband being a professional, had higher number of antenatal care (ANC) visits, seeking ANC from private providers, and delivering in a private facility were associated with higher rates of C-section (Rahman et al. 2018). Moreover, in Bangladesh, children are generally suffering from several common diseases such as fast and/or difficulty of breathing or acute respiratory infection, diarrhea with bloods, fever etc.

However, to the best of our knowledge, there is no research has been conducted to determine the association between C-section and such early childhood diseases in Bangladesh. Hence, it is important to study the consequence of C-section delivery on the child health particularly on the early childhood diseases using a proper statistical method. Therefore, our aim was to investigate the causal association between C-section delivery and childhood diseases using a propensity score method. This study also looks for key factors associated with childhood diseases. The study uses data from the BDHS 2014 and MICS 2012 collected from the nationally representative cross-sectional survey. By identifying key factors, the present study is to assess the data on type of delivery and childhood diseases collected by MICS and DHS and compare C-section measures.

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**2. Methods**

***Data source and Study design***

We used the latest available data from Bangladesh Demographic and Health Survey (BDHS) 2014 data for our study. For comparison, we also used another survey, the multiple indicator cluster survey (MICS, 2012-13) in Bangladesh (BBS and UNICEF 2015). BDHS are large, household surveys produced by the Demographic and Health Surveys Program. The targeted sample is based on nationally representative sampling plans. The surveys emphasize data collection on standardized measures of fertility and child mortality, and indicators of access to maternal and child health interventions, illness, treatment, and nutritional status. These surveys also collect an extensive set of standardized socioeconomic indicators and other such information. These data-sets are fully open-access. There 7886 number of mother-child pairs information was given which represents the seven divisions (Chittagong, Dhaka, Barisal, Sylhet, Rajshahi, Khulna, Rangpur) in Bangladesh. Districts are taken as the main sampling strata for the sample. Among them, the number of children living with their mother is 6650 and about 1236 children don’t live with their mother. From figure 1, 4557 children of three years of age are selected as a sample because BDHS only contains C-Section information of this age of child and 2093 children greater than 3 years are excluded.



**Figure 1: Flow Chart of BDHS data for study population**

MICS are large, standardized, multi-topic household surveys produced by UNICEF. They tend to focus on reproductive health, maternal and child health interventions, child nutritional status, and early childhood development, and use similar methodology and measurement protocols to DHS. MICS also collect a standardized set of socioeconomic characteristics of individuals and households. Data-sets can be accessed in the public domain. MICS is based on a sample of 51,895 households (43,474 rural, 8,421 urban) interviewed with a response rate of 98.5% and provides a comprehensive picture of children and women health in the seven administrative divisions (Dhaka, Chittagong, Sylhet, Rajshahi, Rangpur, Barisal, Khulna) of Bangladesh. Districts were identified as the main sampling strata for the sample selection in 2 stages. In this study, the child age ranged from 0 to 24 months were included; 36197 women have not had child and 15481 babies greater than 24 months were excluded from the analysis. Therefore, the sample included 7921 children and mother information for analysis. Among the 7921 children, the information of type of delivery has only 2181 children and 2122 children have both type of delivery and disease information (Figure 2).



**Figure 2: Flow Chart of MICS data for study population**

Since their inception, DHS and MICS surveys have played an important role in shaping the global agenda on tracking coverage and in populating global databases. They have also influenced policies and intervention strategies. For example, DHS/MICS data are often used to establish targets in national economic and social development plans, to provide advocacy for programs to improve women’s and children’s health, and to assist programs in identifying target groups in most need of interventions. The role that these data play at the national and international level make it imperative that data quality is the foremost consideration when designing surveys and providing estimates of key indicators.

***Potential confounding variables***

We considered important confounding variables and/or covariates including, religion, breastfed status, sex (child), education (mothers), child Age (in months), body mass index (mothers), wealth index quintile, area, division, child's length or height, weight at birth (child) and fathers’ education.

***Exposure variable***

The exposure variable was the type of delivery (C-section versus normal delivery), which is a binary variable.

***Outcome variable***

For creating the outcome variables disease, we used variables such as child did not able to drink or breastfeed, becomes sicker, develops a fever, has fast breathing, has difficulty breathing, has blood in stools, drinking poorly and has diarrhea. During the analyses, two types outcome variables were considered. First, a binary outcome in which 0 means children were suffered from lower than median value (diseases) and 1 means greater than median value (diseases); second, a count variable that means frequency of the diseases. Figure 3 displays the frequency of diseases (count) against

number of babies and the frequency of binary disease (where 0 means lower disease and 1 means higher disease).

***Statistical analyses***

Descriptive statistics of each of the selected confounding variables and distribution of type of delivery were shown by adjusting sampling weight. Similarly, weighted percentages were calculated to compare demographic and socioeconomic characteristics among type of delivery. Pearson’s chi-squared test was used for to determine whether differences in demographic and socioeconomic characteristics were statistically significant between C-section and vaginal delivered babies. We applied a propensity scores method for the first outcome (binary). The propensity score (PS) method is the probability of exposure (C-section versus vaginal delivery) assignment conditional on possible confounding. This method allows us to design and analyze our observational survey data so that it mimics some of the characteristics (covariates) of a randomized controlled trial (Austin 2011). Poisson regression model often display overdispersion, for that reason negative binomial (NB) regression models are perhaps the most convenient to with, and have been used by various authors (10.2307/3314912). Hence for second outcome, we applied a NB regression method with a log link to assess the sensitivity of the results from the PS method. All statistical analyses were performed by SAS 9.4. We reported the crude and adjusted exposure effects.

***Ethics approval***

Our study was wholly based on an analysis of existing public domain health survey datasets obtained from BDHS 2014 and MICS 2012, which is freely available online with all identifier information removed. The BDHS 2014 data was reviewed and approved by the ICF Macro Institutional Review Board and the National Research Ethics Committee of the Bangladesh Medical Research Council. The MICS procedures were reviewed and approved by the Bangladesh Bureau of Statistics (BBS) and UNICEF. Informed consent was obtained from participants while interviewing them. Because this study involves secondary data analyses of a publicly available dataset which does not reveal the identity of the respondents, ethical approval from respective institutions was not required.

**3. Results**

**Descriptive analysis**

Table 1 compares the distribution of mother’s and child’s characteristics separately for BDHS and MICS by different types of delivery (vaginal delivery versus C-section). We found 19.1% of children were born in the C-section and 80.9% of children were born in normally (vaginal delivery) for MICS data. On the other hand, for BDHS, children born in the C-section were 23.3% and rest were born in normal delivery. Women who had undergone a C-section had lower prevalence (11.7%) in higher age groups (35+ years) for MICS but in BDHS data, women with C-section delivery had lower prevalence for lowest age groups (15-19 years). According to MICS, highest prevalence of C-section, 20.0%, was found in the age group 24-34 years and BDHS also shows highest prevalence (23.9%) for similar age groups. Prevalence of C-section was significantly lower in Muslim than non-Muslim with the figures being 18.6% for Muslim and 25.1% for non-Muslim in MICS, but this prevalence is almost similar in BDHS, 23.1% for Muslim and 24.8 for non-Muslim. The highest percentages of C-section were delivered in Khulna 30.5% in MICS and 33.3% in BDHS, on the other hand, women’s lives in Barisal has lowest percentage of C-section (10.5%) according to MICS and (10.9%) C-section delivery was conducted in Sylhet according to BDHS. But, according to MICS, Sylhet is the second lowest (10.8%) district where C-section delivery conducted compared to all other district in Bangladesh.

As expected, the prevalence was higher among the children of mothers with secondary complete or higher education. The prevalence of C-section among the children whose mothers have secondary complete or higher education was 47.6%, on the other hand, the prevalence was lower (5.5%) among the children of mothers with no education. In BDHS, this prevalence is reported as more acute (54.9%) for highly educated mother comparing to MICS data. Both BDHS and MICS reports give similar result for household wealth quintile, the prevalence among the richest wealth quintile was 46.5% in MICS and 51.9% in BDHS, which is declined to 5.4% in MICS and 6.7% in BDHS among the poorest wealth quintile. There was a significant rural urban gap in prevalence of C-section in both data. Children living in rural areas being delivered by C-section was highest and the prevalence is 33.1% in MICS data versus 15.4% of children living in urban areas. In BDHS, it is 17.9% in rural versus 38.7% in urban. Children born by C-section delivery was highly prevalence in overweight mother at resulted by both MICS and BDHS data. The prevalence of overweight children born by C-section is 27.3% and 43.3% according to MICS and BDHS, respectively. According to child age, 19.6% (MICS) and 24.6% (BDHS) child were born by C-section which lay between the age group of 0-11 months. But, it lowest in highest age group (12-23) in MICS (18.6%) and in BDHS (21.1%). Size of child is statistically significant at 5% level of significance with C-section. According to MICS, very large child has highest prevalence (45.5%) to borne by C-section and it declines at 16.5% when child size is very small. However, this result is contradictory with BDHS, according to BDHS, highest C-section delivery occurred in large (larger than average) child and the prevalence is 32.3%.

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| Table 1: Distribution of parents and child characteristics with type of delivery | | | | | | |
|  | MICS 2012 | | | BDHS 2014 | | |
|  | Type of Delivery | | | Type of Delivery | | |
| Variable | Caesarean  N (%) | Vaginal  N (%) | P-value | Caesarean  N (%) | Vaginal  N (%) | P-value |
| **Mother Age** |  | | | | | |
| 15-19 | 171 (18.8) | 740 (81.2) | 0.000 | 191 (21.0) | 745 (79.0) | 0.402 |
| 20-34 | 1241 (20.0) | 4952 (80.0) |  | 802 (23.9) | 2550 (76.1) |  |
| 35+ | 93 (11.7) | 700 (88.3) |  | 69 (23.7) | 200 (76.3) |  |
| **Religion** |  | | | | | |
| Islam | 1343 (18.6) | 5894 (81.4) | 0.000 | 961 (23.1) | 3236 (76.9) | 0.705 |
| Other religion (Hinduism, Buddhism, Christianity) | 167 (25.1) | 498 (74.9) |  | 101 (24.8) | 259 (75.2) |  |
| **Division** |  | | | | | |
| Barisal | 50 (10.5) | 428 (89.5) | 0.000 | 105 (18.1) | 435 (81.9) | 0.000 |
| Chittagong | 267 (14.5) | 1577 (85.5) |  | 169 (18.2) | 716 (81.8) |  |
| Dhaka | 604 (24.4) | 1872 (75.6) |  | 262 (30.0) | 548 (70.0) |  |
| Khulna | 230 (30.5) | 524 (69.5) |  | 182 (33.3) | 346 (66.7) |  |
| Rajshahi | 189 (22.4) | 656 (77.6) |  | 148 (22.5) | 406 (77.5) |  |
| Rangpur | 104 (11.7) | 788 (88.3) |  | 108 (17.9) | 440 (81.1) |  |
| Sylhet | 66 (10.8) | 547 (89.2) |  | 88 (10.9) | 604 (89.1) |  |
| **Mother's education** |  | | | | | |
| None | 80 (5.5) | 1378 (94.5) | 0.000 | 43 (7.1) | 571 (92.9) | 0.000 |
| Primary incomplete | 78 (7.5) | 964 (92.5) |  | - | - |  |
| Primary complete | 142 (11.5) | 1096 (88.5) |  | 145 (11.8) | 1112 (88.2) |  |
| Secondary incomplete | 660 (21.9) | 2360 (78.1) |  | 572 (28.1) | 1580 (71.9) |  |
| Secondary complete/ higher | 539 (47.6) | 594 (52.4) |  | 302 (54.9) | 232 (45.1) |  |
| **Wealth Index** |  | | | | | |
| Poorest | 98 (5.4) | 1717 (94.6) | 0.000 | 52 (6.7) | 913 (93.3) | 0.000 |
| Poorer | 136 (8.7) | 1436 (91.3) |  | 99 (10.6) | 763 (89.4) |  |
| Middle | 192 (12.8) | 1308 (87.2) |  | 165 (18.6) | 709 (81.4) |  |
| Richer | 351 (25.1) | 1046 (74.9) |  | 275 (29.5) | 673 (70.5) |  |
| Richest | 735 (46.5) | 847 (53.5) |  | 471 (51.9) | 437 (48.1) |  |
| **Body Mass Index** |  | | | | | |
| Underweight | 50 (13.5) | 320 (86.5) | 0.000 | 153 (14.2) | 1005 (85.8) | 0.000 |
| Normal | 1034 (17.3) | 4934 (82.7) |  | 568 (21.6) | 2051 (78.4) |  |
| Overweight | 427 (27.3) | 1138 (72.7) |  | 336 (43.3) | 426 (56.7) |  |
| **Area** |  | | | | | |
| Urban | 548 (33.1) | 1110 (66.9) | 0.000 | 532 (38.7) | 925 (61.3) | 0.000 |
| Rural | 963 (15.4) | 5282 (84.6) |  | 530 (17.9) | 2570 (82.1) |  |
| **Breastfeed** |  | | | | | |
| Yes | 1483 (19.3) | 6208 (80.7) | 0.020 | 891 (77.5) | 3011 (66.1) | 0.018 |
| No | 27 (12.9) | 183 (87.1) |  | 171 (27.8) | 484 (72.2) |  |
| **Sex (child)** |  | | | | | |
| Male | 784 (19.6) | 3226 (80.4) | 0.331 | 575 (24.1) | 1768 (75.9) | 0.205 |
| Female | 727 (18.7) | 3166 (81.3) |  | 487 (22.4) | 1727 (77.6) |  |
| **Child age in months** | | | | | | |
| 0-11 | 766 (19.6) | 3138 (80.4) | 0.264 | 372 (24.6) | 1090 (75.4) | 0.168 |
| 12-23 | 744 (18.6) | 3254 (81.4) |  | 375 (24.2) | 1182 (75.8) |  |
| 24-35 | - | - |  | 315 (21.1) | 1223 (78.9) |  |
| **Size at birth** |  |  |  |  |  |  |
| Very large | 5 (45.5) | 6 (54.5) | 0.000 | 23 (20.0) | 78 (80.0) | 0.009 |
| Larger than average | 326 (31.2) | 718 (68.8) |  | 154 (32.4) | 327 (67.6) |  |
| Average | 881 (18.8) | 3794 (81.2) |  | 710 (22.7) | 2379 (77.3) |  |
| Smaller than average | 228 (16.7) | 1134 (83.3) |  | 118 (19.4) | 480 (80.6) |  |
| Very small | 44 (16.5) | 222 (83.5) |  | 57 (23.8) | 230 (76.1) |  |
| **Total** | 1510 (19.1) | 6392 (80.9) |  | 1062 (23.3) | 3495 (76.7) |  |

Table 2 shows the results from crude estimates of PS and NB regression. From the PS method, we found the crude (only type of delivery variable in the model) model had significantly higher 1.60 (95% confidence interval (CI): 1.30-1.97) and risk ratios (RR) for the C-section were 1.11 (95% CI: 1.01-1.23) for MICS and BDHS, respectively, though the association was not statistically significant for C-section at 5% level of significance. Similarly, the crude estimates from the NB regression analysis showed that the risk ratio (RR) for the C-section was 1.06 (95% CI: 1.02-1.09) for MICS and 1.08 (CI: 0.97-1.19) for BDHS, respectively, which indicates that children were born in C-section compare to the vaginal delivery were at increased risk for developing childhood disease. However, the association was not statistically significant in the crude model (crude p-value=0.159) for BDHS data but significant for MICS data (crude p-value=0.001). This result is also similar with S1 table. Hence, both methods and both data showed similar conclusions.

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| Table 2: Parameter estimates from the Propensity Scores and the Poisson Regression methods for crude model | | | | | | | |
|  |  | Crude Estimates | | | | | |
|  |  | MICS 2012 | | | BDHS 2014 | | |
| Method | Exposure | RR | 95% CI | P-value | RR | 95% CI | p-value |
| PS | C-section vs.  Vaginal delivery | 1.60 | 1.30-1.97 | 0.000 | 1.11 | 1.01-1.23 | 0.042 |
| NB | C-section vs.  Vaginal delivery | 1.06 | 1.02-1.09 | 0.001 | 1.08 | 0.97-1.19 | 0.159 |

Table 3 depicts that, RR for adjusted (type of delivery and propensity scores in the model) model was 1.19 (CI: 0.99-1.43) for MICS and 1.17 (1.05-1.29) for BDHS, respectively. Similarly, the adjusted estimates from the NB regression analysis showed that the risk ratio (RR) for the C-section was 1.02 (95% CI: 0.98-1.06) for MICS and 1.15 (CI: 1.05-1.27) for BDHS, respectively. That means the babies born in C-section has higher in risk for getting diseases than the vaginal delivery. When adjusting other confounding variable, the association was not statistically significant at 5% level of significance in adjusted model (adjusted p-value=0.068 (PS) and adjusted p-value=0.253 (NB)) in both method for MICS data but BDHS data shows significant in both adjusted methods.

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| Table 3: Parameter estimates from the Propensity Scores methods for adjusted model | | | | | | | |
|  |  | Adjusted Estimates | | | | | |
|  |  | MICS 2012 | | | BDHS 2014 | | |
| Method | Exposure | ARR\* | 95% CI | p-value | ARR\* | 95% CI | p-value |
| PS | C-section vs.  Vaginal delivery | 1.19 | 0.99-1.43 | 0.068 | 1.17 | 1.05-1.29 | 0.030 |
| NB | C-section vs.  Vaginal delivery | 1.02 | 0.98-1.06 | 0.253 | 1.15 | 1.05 - 1.27 | 0.004 |

**Risk factors associated with childhood diseases due to C-section delivery**

NB regression analysis for the status of childhood diseases reveals that the division, the level of education of the mother, wealth index and child size at birth were the main contributing factors to childhood diseases due to type of delivery in MICS. In MICS, type of delivery, BMI, child sex and child age were the main contributing factors to childhood diseases due to type of delivery (S2 Table).

Table 4 shows the association between type of delivery and early childhood diseases when models adjusted for possible confounding factors. For instance, after adjusting all other factors, MICS explained that C-section delivered babies were 1.02 times (CI: 0.98–1.06) more likely to be affected by diseases and it is 1.15 times (CI: 1.05-1.27) more acute in BDHS. The risk of the children getting affected by diseases whose mothers aged between 15-19 years were 1.11 (CI: 0.97-1.26) more likely and aged between 20-34 years were 0.91 (CI: 0.76-1.09) less likely than those aged above years, respectively. Both MICS and BDHS explained similar conclusion, in BDHS, the mothers aged between 15-19 years were 1.05 (CI: 0.95-1.15) more likely and aged between 20-34 years were 0.91 (CI: 0.87-1.06) less likely to effected by diseases than those aged above, respectively.

According to MICS, Childs living with her mother with above secondary 0.94 (CI: 0.89–1.00), who had secondary incomplete 0.92 (CI: 0.86–0.98), who had primary completed 0.98 (CI: 0.92-1.04) or who had primary incomplete 0.97 (CI:0.92-1.03) were times less likely associated with diseases due to types of delivery, compared to their peers living with mothers who ever not attended any school. In BDHS, similar to MICS, child who belongs to mothers with academic background is less likely to get affected by diseases compared to mothers who hadn’t any academic qualifications. Childs who identify as belonging to the richest family were more likely to get effected by diseases due to C-section delivery (ARR = 1.03, 95% CI 1.00–1.07) and (ARR=1.17, 95% CI 1.03-1.34) in both MICS and BDHS, respectively.

Children who born from underweight and overweight mothers were more likely to be getting disease, ARR 1.06 (95 % CI: 1.00-1.13) and ARR 1.08 (95 % CI: 1.01-1.16) in MICS and ARR 1.13 (95 % CI: 1.01-1.26) and ARR 1.17 (95 % CI: 1.03-1.32) in BDHS, due to C-section. Children who breastfed were 4 % (MICS) and 9% (BDHS) less likely to manifest diseases. Age of the children is recognized as an important factor for childhood diseases, and results showed that children with age between 0-11 months and 12-23 months were more at risk of suffering from diseases than 24–35 months aged children, ARR 1.15 (95 % CI: 1.04-1.27, p < 0.006) and ARR 1.14 (95 % CI: 1.04-1.26, p < 0.005). An unexpectedly and approximately similar ARR was found for children from rural areas in both MICS and BDHS data.

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| Table 4: Influence of factors associated with childhood diseases (lower diseases and vaginal delivery vs. higher diseases due to C-section delivery). | | | | | | |
|  | Adjusted Estimates | | | | | |
|  | MICS 2012 | | | BDHS 2014 | | |
|  | ARR\* | 95% CI | p-value | ARR\* | 95% CI | p-value |
| Source |  |  |  |  |  |  |
| **Type of Delivery** |  |  |  |  |  |  |
| C-section | 1.02 | 0.98-1.06 | 0.253 | 1.15 | 1.05 - 1.27 | 0.004 |
| Vaginal | 1 | - | - | 1 | - | - |
| **Mother’s Age at birth** |  |  |  |  |  |  |
| 15-19 | 1.11 | 0.97-1.26 | 0.021 | 1.05 | 0.95-1.15 | 0.182 |
| 20-34 | 0.91 | 0.76-1.09 | 0.174 | 0.96 | 0.87-1.06 | 0.376 |
| 35+ | 1 | - | - | 1 | - | - |
| **Religion** |  |  |  |  |  |  |
| Islam | 0.99 | 0.95-1.04 | 0.812 | 1.06 | 0.92-1.21 | 0.431 |
| Other religion (Hinduism, Buddhism, Christianity) | 1 | - | - | 1 | - | - |
| **Division** |  |  |  |  |  |  |
| Barisal | 0.81 | 0.76-0.87 | 0.000 | 1.00 | 0.85-1.17 | 0.981 |
| Chittagong | 0.83 | 0.78-0.87 | 0.000 | 1.07 | 0.94-1.22 | 0.319 |
| Dhaka | 0.88 | 0.83-0.92 | 0.000 | 0.94 | 0.82-1.07 | 0.339 |
| Khulna | 1.00 | 0.95-1.06 | 0.973 | 1.04 | 0.89-1.21 | 0.636 |
| Rajshahi | 0.83 | 0.78-0.88 | 0.000 | 0.96 | 0.83-1.11 | 0.554 |
| Rangpur | 0.95 | 0.89-1.01 | 0.081 | 0.90 | 0.77-1.01 | 0.160 |
| Sylhet | 1 | - | - | 1 | - | - |
| **Mother's education** |  |  |  |  |  |  |
| None | 0.94 | 0.89-1.00 | 0.049 | 0.89 | 0.75-1.05 | 0.166 |
| Primary incomplete | 0.92 | 0.86-0.98 | 0.007 | 0.91 | 0.81-1.03 | 0.154 |
| Primary | 0.98 | 0.92-1.04 | 0.577 | 0.98 | 0.87-1.11 | 0.780 |
| Secondary incomplete | 0.97 | 0.92-1.03 | 0.320 | - | - | - |
| Secondary complete higher | 1 | - | - | 1 | - | - |
| **Wealth Index** |  |  |  |  |  |  |
| Richest | 1.03 | 1.00-1.07 | 0.051 | 1.17 | 1.03-1.34 | 0.191 |
| Richer | 1.07 | 1.03-1.11 | 0.000 | 1.11 | 0.96-1.28 | 0.148 |
| Middle | 1.04 | 1.00-1.09 | 0.046 | 1.10 | 0.95-1.28 | 0.019 |
| Poorer | 1.08 | 1.03-1.14 | 0.003 | 1.11 | 0.98-1.25 | 0.110 |
| Poorest | 1 | - | - | 1 | - | - |
| **Body Mass Index** |  |  |  |  |  |  |
| Underweight | 1.06 | 1.00-1.13 | 0.043 | 1.13 | 1.01-1.26 | 0.025 |
| Overweight | 1.08 | 1.01-1.16 | 0.032 | 1.17 | 1.03-1.32 | 0.015 |
| Normal | 1 | - | - | 1 | - | - |
| **Area** |  |  |  |  |  |  |
| Urban | 1.02 | 0.97-1.06 | 0.469 | 1.00 | 0.91-1.10 | 0.969 |
| Rural | 1 | - | - | 1 | - | - |
| **Breastfeed** |  |  |  |  |  |  |
| Yes | 0.96 | 0.81-1.14 | 0.634 | 0.91 | 0.81 – 1.02 | 0.066 |
| No | 1 | - | - | 1 | - | - |
| **Sex (child)** |  |  |  |  |  |  |
| Male | 1.00 | 0.97-1.03 | 0.822 | 1.08 | 1.00-1.16 | 0.039 |
| Female | 1 | - | - | 1 | - | - |
| **Child age** |  |  |  |  |  |  |
| 0-11 | 1.00 | 0.97-1.03 | 0.951 | 1.15 | 1.04-1.27 | 0.006 |
| 12-23 | 1 | - | - | 1.14 | 1.04-1.26 | 0.005 |
| 24-35 | - | - | - | 1 | - | - |
| **Size at birth** |  |  |  |  |  |  |
| Very large | 0.88 | 0.70-1.10 | 0.249 | 0.96 | 0.73-1.27 | 0.795 |
| Larger than average | 0.90 | 0.72-1.12 | 0.341 | 0.95 | 0.79-1.14 | 0.585 |
| Average | 0.87 | 0.69-1.09 | 0.213 | 0.93 | 0.80-1.07 | 0.314 |
| Smaller than average | 0.99 | 0.78-1.24 | 0.900 | 1.07 | 0.90-1.27 | 0.418 |
| Very small | 1 | - | - | 1 | - | - |

*RR: Risk Ratio; CI: Confidence Interval; ARR: Adjusted risk ratio*

*\*Model adjusted with Propensity scores \*\*Model adjusted with confounding and/or covariates*

**4. Discussion**

We examined the causal association between C-section delivery (versus vaginal delivery) and the early childhood diseases in Bangladesh. The PS and NB regression methods showed that the odds of having childhood diseases were higher for the C-section babies as compared to the vaginal delivery babies. A similar study observed that C-section is associated with an increased risk of immune development, an increased likelihood of allergy, atopy, and asthma, and reduced intestinal gut microbiome diversity (10.1016/S0140-6736(18)31930-5). Two meta-analysis, which conducted with the delivery by C-section children, were found to be associated with a moderately increased risk of allergic rhinitis, asthma, perhaps food allergy and type 1 diabetes in children born by Caesarean section (10.1111/j.1365-2222.2008.02939.x & 10.1007/s00125-008-0941-z). Similar result was observed by Baral N et al, where they have shown an increased risk of acute lymphoblastic leukaemia in young children born by caesarean delivery (10.1016/S2352-3026(16)00002-8). In contracts, there was no statistically significant association of mode of delivery with the development of childhood wheeze at up to 5 years, but at 6–15 years follow-up, cesarean delivery was associated with increased odds of wheeze in children when compared with those delivered vaginally ([10.1371/journal.pmed.1002494](https://doi.org/10.1371/journal.pmed.1002494)). Although the risk is higher, after adjusting for all possible confounding variables, we did not identify any significant causal association between C-section and childhood diseases in BDHS data for crude estimates and in MICS data for both estimates.

The analyses of this study confirmed that childhood disease is associated with maternal age. In earlier studies, Kandala et al., 2006 ([**10.1002/asmb.624**](https://doi.org/10.1002/asmb.624)), children born to younger mothers (aged <20 years) were found to have a relatively high risk of diarrhea, cough and fever in their young children, probably because the relationship between maternal age is related with some adverse pregnancy outcomes and higher risk of medical conditions like hypertension, diabetes or other factors.

From our findings, we have seen that the rate of C-section delivery was higher particularly in the Khulna division compared to other divisions of Bangladesh according to MICS data and it is also similar in BDHS survey. A previous study has demonstrated that the women of Chittagong, Dhaka, Khulna and Rajshahi division were more likely to avail of institutional delivery and caesarean sections. Where, it is low in Barisal division and Sylhet division (10.3329/jhpn.v31i1.14754). The risk of diseases did not differ noticeably across the divisions. For instance, the risk ratio of getting diseases is similar to the prevalence. The risk of disease was higher in Khulna in MICS survey and it is also higher in Barisal and Chittagong. It is evident that the Barisal, Chittagong and Sylhet division have higher rates of vacancies of service providers, and the use of maternity care services in these particular divisions is lower. Besides, Dhaka, Khulna and Rajshahi division have less vacant posts for healthcare providers, resulting in the higher use of maternity care services in these administrative regions (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3702364/>).

As expected, among the educated women, the highest rate of C-section was occurred among secondary completed or higher educated women. We also observed that lower risk of diseases occurred for C-section babies than children born by vaginal delivery in all other education level of mother compared to this group. Since the education is directly related to the autonomy of women, they are economically more solvent and mostly living in urban areas, may decide to give birth through a C-section. However, some studies reported no visible link between women's preference for C-section and their level of education (Angeja et al. 2006; Chu et al. 2010).

In terms of wealth, use of healthcare facilities for childbirth was higher among the richest adolescent girls compared to those belonging to the middle and poorer wealth bands. Rates of caesarean sections were also higher among richer adolescents compared to those belonging to the poorest or poorer wealth bands (<https://bmjopen.bmj.com/content/6/9/e012424>). This might be a reason of high risk of diseases in richest group in our study. However, financial stress is strongly correlated with child undernutrition, poor cognitive development, and weakened immune system, so can increase the vulnerability to infectious diseases. Children in financially well-off families are more likely to enjoy healthy and secure living facilities with greater access to health-promoting conditions in comparison to those from impoverished families in later life (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6473378/>).

Our study has some important strengths. First, we used data that is latest available nationally representative data; second, to our knowledge, this is the first study to assess the causal association between C-section and early childhood diseases in Bangladesh; third, we used modern and classical statistical methods and found consistent results between methods. This may indicate a validity our findings; fourth, we did a comparative study between two largest nationally representatives survey.

However, there are some limitations of our study: first, considering target population of this survey, a big percentage of children do not have type of delivery information and the power of the study was low and, hence, we may not be identified any significant association. To increase the power, further study could be considered using multiple imputation; secondly, some important factors related to maternal and child health were not provided in the data we have used, finally, as this is a cross-sectional study, causal association based such study may questionable. We made several recommendations for policymakers, service providers and mothers. Firstly, health awareness and educational programs should be given to focus on negative impacts of unnecessary C-section and advantage of vaginal delivery. In that case, complete and reliable information should be provided to the pregnant women so that they do not go for unnecessary C-section in a state of panic or ignorance; secondly, national health policy should be made for hospitals, doctors and nurses to avoid unnecessary C-section.

**Conclusion**

In conclusion, although the C-section babies were in increased risk for getting disease, we did not identify any significant causal association between the type of delivery and the childhood diseases in some model. An increase in the rates of caesarean section delivery is a burden on the health system and childhood diseases. Unnecessary caesarean delivery also put a strain on family and may complicate maternal and child health. Therefore, the decision to perform a C-section delivery must be chosen carefully and should not be profit oriented.

To reduce unnecessary C-sections and encourage vaginal birth, various strategies must be taken, such as the implementation of standardized protocols, request of a second medical opinion prior to surgery, improving maternal empowerment during pregnancy and delivery, maternal and medical collaboration on birth plans, alternatives to endure labor pain and creation of pleasurable labor environments.

Longitudinal studies are therefore necessary to increase our knowledge on the impact of C-section delivery on the development of early childhood diseases, the incidence of chronic immune and metabolic disorders in developing countries, including Bangladesh.

However, we recommend increasing public awareness for the negative impact of the unnecessary caesarean delivery in Bangladesh. In addition, training of hospital staff, health officers, midwives and health extension workers in emergency obstetric care as well as neonatal resuscitation skills, and use of partograph for appropriate decision to undertake C-Section are critical. Nurses and midwives should explain carefully the benefits and the possible risk/complication associated with CS to clients at antenatal clinic. All available birthing methods should also be explained giving the merit and demerits to the clients during antenatal clinic sessions.

**References**

**Supporting information**

**S1 Table: Unadjusted LR statistics for type 3 analysis**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | MICS 2012 | | BDHS 2014 | |
| **Source** | **Chi-Square** | **P-value** | **Chi-Square** | **P-value** |
| **Type of Delivery** | 9.97 | 0.002 | 1.88 | 0.170 |

**S2 Table: Adjusted LR Statistics for Type 3 Analysis**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | MICS 2012 | | BDHS 2014 | |
| Covariates | **Chi-Square** | **P-value** | **Chi-Square** | **P-value** |
| **Type of Delivery** | 1.29 | 0.257 | 8.24 | 0.004 |
| **Mother Age** | 5.56 | 0.062 | 2.06 | 0.357 |
| **Religion** | 0.06 | 0.813 | 0.62 | 0.429 |
| **Division** | 113.01 | 0.000 | 9.48 | 0.148 |
| **Mother's education** | 12.87 | 0.012 | 3.76 | 0.288 |
| **Wealth Index** | 15.52 | 0.004 | 5.71 | 0.222 |
| **Body Mass Index** | 4.75 | 0.093 | 6.41 | 0.041 |
| **Area** | 0.52 | 0.472 | 0 | 0.969 |
| **Breastfeed** | 0.23 | 0.632 | 2.63 | 0.105 |
| **Sex (child)** | 0.05 | 0.822 | 4.26 | 0.039 |
| **Child age** | 0.00 | 0.951 | 9.71 | 0.008 |
| **Size at birth** | 11.50 | 0.022 | 7.63 | 0.106 |